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Evaluation of Chickpea Lines/Mutants for High Growth and Yield Attributes

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ABSTRACT

A study was undertaken to evaluate the performance of 23 advanced chickpea mutants/lines along with two check varieties Binasola-3 and Binasola-4 at the farmer's field in Godagari under Rajshahi district during 2006-2007. There was a significant genotypic difference with respect to morphological, physiological, phenological characters, and yield and yield components. Seed yield was positively correlated with plant height, primary and secondary branches, total dry matter (TDM) and number of pods per plant but negatively correlated with days to flowering, days to maturity and protein content. Four mutants/lines viz., CPC-814, CPC-830, CPM-825 (gr) and CPM-834 showed early maturity, higher number of pods and seed yield per plant than all the studied entries, which might be selected for further trials. The highest seed yield (6.93 g plant^{-1}) was recorded in CPC-830. The line CPC-814 produced the highest number of filled pods per plant and the mutant CPM-834 took the shortest days to maturity. Only the mutant CPM-825 (gr) had distinct greenish seed coat color, which could be a genetic marker for identification of developed chickpea genotypes. It was evident that taller plants with higher number of branches and TDM per plant produced higher number of pods per plant as well as seed yield.

Keywords: Chickpea; Mutant/lines; Morpho-physiological; Phenological; Yield attributes

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the 3rd most important food legume globally, grown in over 40 countries across the globe (Upadhyaya *et al*., 2006). It was originated in western Asia and then spread to India and Europe. Chickpea is a highly nutritious pulse and places third in the importance list of the food legumes that are cultivated throughout the world. Chickpea or gram is one of the most important pulse crops in Indo-Pak subcontinent being used as 'Dal' by majority people. Pulses cover an area of 239.9 thousand hectare of which chickpea occupies about 12.55 thousand hectare and contributes approximately 3.65% to the total pulse production in Bangladesh with an average yield of about 766 kg ha^{-1} (BBS, 2006).

In the developing countries like Bangladesh, pulse can improve the overall nutritional value of cereal based diet. Unfortunately, there is an acute shortage of pulse in relation to their demand in the country. The daily consumption of pulses in Bangladesh is only 12 g head^{-1}, which is very low as compared to standard, 45 g head^{-1} (FAO, 2002). So, domestic pulse production should be increased to meet the increasing demand. Chickpea is an important source of proteins for millions of people in developing countries. It contains 25% proteins, which is the maximum provided by any pulse and 60% carbohydrates (Gaur *et al*., 2008). Cultivation of chickpea can improve the physical, chemical and biological properties of soil. It can also increase the soil fertility status through biological nitrogen fixation from the atmosphere (Upadhyaya *et al*., 2006).

The area under chickpea cultivation has been decreasing at a rapidly, because of increasing demand for staple grains like rice and wheat. This situation is becoming more severe day by day, because of the poor yield of pulses compared to cereals. The major constraints responsible for low yield of chickpea includes low yield potential, sensitive to high water and fertilizer application, sensitive to climatic factors as excess soil moisture/humidity and rainfall compared with cereals. In barind (The North-Western part of Bangladesh) 0.8 million hectare land typically remains fallow during boro season due to scarcity of water for boro rice. Chickpea is well adapted to growing on residual soil moisture, because of its prolific and deep rooting characteristics; hence it has advantages over other post-rainy season crops (Ali *et al*., 2002). Varietals improvement of chickpea is essentially needed to increase seed yield by creating variability in the available germplasm followed by appropriate selection procedure. The induced mutation is an effective breeding technique for creating substantial genetic variation in the plant species. The technique is being

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successfully utilized by Bangladesh Institute of Nuclear Agriculture, Mymensingh, and many other research institutes in the world. The most logical way to increase the total production of chickpea from our limited land resources is to increase yield per unit area. It is, therefore, necessary to create variability and select desirable type with stable yield.

The Plant Breeding Division of BINA has developed several high yielding chickpea mutants. These mutants need to be assessed for their morphological and physiological traits in comparison with the existing chickpea cultivars. The present research work has been designed to study different physiological and agronomic characters and their relation with in newly developed chickpea lines.

MATERIALS AND METHODS

The experiment was conducted at the farmer's field (Godagari Upazila, Rajshahi District) in the-High Barind Tract (HBT) in north-western Bangladesh during the rabi season extended 2006-2007. This region has a distinct physiography of terraced lands at about 30 m above sea level situated at a latitude of 24°25' to 25°10'N and longitude 88–89°E. The region is characterized by low annual rainfall (1363 ± 311 mm) compared with other parts of Bangladesh with uneven rainfall distribution and wide variation from year to year. The grey terrace soil (Aeric Haplaquept) of HBT has a low organic matter content (0.8–1.2 %) and pH (5.5–6.5), a thick ploughpan at 9–12 cm below the surface and poor internal drainage. The high compactness of soil hampers root penetration of crops as well as water infiltration and soil moisture storage. The available soil moisture in the rabi season is in the range of 150–197 mm m^{-1} soil depth (Anonymous, 1991; Ali *et al.*, 1999).

The land was opened in early November 2006 by power tiller. Fertilizers were applied at the time of final land preparation (two ploughings at a depth of 10–12 cm by power tiller & subsequently two ladderings) in equal dose for all plots were N (20 kg ha^{-1}) as urea, P (60 kg ha^{-1}) as TSP, K (40 kg ha^{-1}) as muriate of potash, S (10 kg ha^{-1}) as gypsum, Zn (3 kg ha^{-1}) as zinc sulphate and B (1 kg ha^{-1}) as boric acid.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The experiment was comprised of 12 chickpea lines namely P-70, CPC-811, CPC-814, CPC-816, CPC-818, CPC-820, CPC-821, CPC-823, CPC-824, CPC-825, CPC-826, CPC-830, 11 chickpea mutants namely CPM-825 (gr), CPM-834, CPM-840, CPM-841, CPM-846, CPM-848, CPM-849, CPM-851, CPM-855, CPM-858, CPM-860 and 2 check varieties viz. Binasola-3, Binasola-4. The seeds were collected from Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh.

Seeds were sown on the 13^{th} November, 2006 in 40 cm apart rows and plant to plant distance of 5-7 cm. Seeds were uniformly distributed to maintain uniform plant population in each plot. The crop was grown under non-irrigated condition as it is normally grown in soil moisture conserved from the preceding monsoon. Weeding was done at 20 and 40 days after sowing (DAS). Dimecron (0.02%) was applied to control pod borer infestation. All the plants of the given plots were harvested when most of the pods become mature.

Collection of data. Data were taken from randomly selected 10 plants from each plot. Data on plant height (cm), number of primary and secondary branches per plant, days required to 1^{st} flowering, days required to 50% flowering, days required to maturity, total dry matter per plant (g), number of filled and false pods per plant, number of seeds per pod, 100 seed weight (g), seed yield per plant (g), seed yield per plot (kg ha^{-1}), protein content (%). Harvest index was estimated by dividing economic yield to biological yield and expressed as percentage.

$$\text{Harvest index} = \frac{EY}{BY} \times 100$$

Where, EY= Economic yield, BY= Biological yield.

Estimation of total nitrogen and protein percentage. Total nitrogen contents were determined by Kjeldhal method and protein contents were determined by multiplying nitrogen percentage 6.25 (Anonymous, 1980).

Statistical analysis. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncan's Multiple Range Test (DMRT) and simple correlation co-efficient between important character were also carried out using the statistical computer package program, MSTAT-C.

RESULTS AND DISCUSSION

Plant height of different genotypes was significantly different amongst them CPC-814 being the tallest (56.2 cm) from all the studied entries. Nonetheless, it was similar with CPC-811 (53.6 cm) and CPM-860 (55.3 cm). In contrast, plant height of CPC-826 was minimum (41.2 cm) and was similar to CPC-821 (43.3 cm), CPC-824 (43.3 cm) and CPM-858 (43.7 cm) (Table I). It was evident that some mutants/lines showed higher and some showed lower plant height compared to parent Binasola 3 and check variety, Binasola 4, which reflected the variability in respect of plant height created by gamma irradiation.

The number of primary branches per plant was significantly different in chickpea mutants/lines/varieties. However, there was least variability in primary branches than all other morphological characters of the studied genotypes ranging from 2.0 to 3.6 per plant (Table I). Maximum number of primary branches per plant were recorded in CPC-830 (3.6) followed by CPC-814 (3.3). Whilst 15 mutants produced lower number of primary branches ranging from 2.0 to 2.3 per plant and seven mutants produced the lowest, only 2.0 branches per plant.

Table I. Some morphological and phenological characters of studied 25 chickpea genotypes

Mutants/ lines/ varieties	Plant height (cm)	Primary branches plant^{-1}	Secondary branches plant^{-1}	Days to 1st flowering	Days to 50% flowering	Days to maturity	Total dry matter (g plant^{-1})	Harvest index (%)	Protein content (%)
P-70	48.1 de	3.0 b	6.2 d	77 e-g	84 ef	131 bc	12.21 d-f	26.6 d-i	19.4 ij
CPC-811	53.6 ab	3.0 b	7.0 a-c	78 f-h	84 ef	126 h-j	13.16 a-c	28.8 b-e	22.6 b-f
CPC-814	56.2 a	3.3 ab	7.2 ab	79 b-e	86 b-e	125 j-l	13.24 ab	30.3 b	21.9 e-g
CPC-816	45.7 e-h	2.6 c	5.2 e	79 b-e	85 c-e	131 bc	11.21 d-j	26.3 e-i	20.5 g-i
CPC-818	47.2 d-f	2.3 cd	6.5 cd	76 f-h	87 b-d	126 h-j	12.37 b-e	27.7 b-g	23.4 a-e
CPC-820	45.5 e-h	2.3 cd	5.0 ef	77 e-h	84 ef	128 fg	11.78 e-h	22.4 j-l	21.2 f-h
CPC-821	43.3 g-i	2.0 d	4.4 f-h	81 b	87 a-c	130 c-e	10.86 f-j	24.8 h-j	22.2 b-g
CPC-823	45.2 e-h	2.3 cd	4.6 e-h	80 bc	87 a-c	130 b-d	11.17 e-j	24.4 i-k	22.2 b-g
CPC-824	43.3 g-i	2.0 d	4.4 f-h	76 f-h	86 b-e	132 b	10.13 ij	25.9 g-i	23.2 a-e
CPC-825	49.4 cd	2.3 cd	5.2 e	75 h	82 gh	128 fg	12.11 f	27.6 b-h	22.9 a-f
CPC-826	41.2 i	2.0 d	4.2 gh	75 h	83 fg	126 i-k	10.22 ij	25.5 g-i	21.9 d-g
CPC-830	52.5 bc	3.6 a	7.6 a	72 i	80 hi	129 d-f	14.49 a	32.6 a	18.7 j
CPM-825 (gr)	49.7 cd	3.0 b	6.6 b-d	71 i	79 i	125 kl	12.65 b-d	28.3 b-f	23.9 a-c
CPM-834	47.8 d-f	3.0 b	6.6 b-d	61 j	70 j	120 m	14.00 a	29.4 bc	20.1 h-j
CPM-840	43.1 g-i	2.3 cd	4.6 e-h	79 b-e	88 a-c	128 fg	10.28 ij	25.1 g-i	22.3 b-g
CPM-841	43.1 g-i	2.0 d	4.2 gh	83 a	89 a	127 g-i	10.23 ij	22.1 kl	22.2 b-g
CPM-846	44.6 f-i	2.6 c	4.8 e-g	81 b	87 a-c	128 f-h	12.16 b-f	26.6 d-i	24.1 a
CPM-848	42.5 hi	2.0 d	4.0 h	76 gh	84 d-f	125 j-l	10.49 h-j	25.4 g-i	22.7 a-f
CPM-849	46.3 d-g	2.3 cd	4.7 e-g	79 b-e	86 b-e	129 ef	9.94 ij	26.2 e-i	22.5 b-f
CPM-851	44.1 f-h	2.0 d	4.2 gh	82 a	88 ab	135 a	9.76 j	20.6 l	23.8 a-d
CPM-855	44.1 f-h	2.3 cd	4.6 e-g	80 bc	88 ab	129 d-f	11.96 b-g	27.4 c-h	24.6 a
CPM-858	43.7 g-i	2.0 d	4.2 gh	75 h	86 b-e	128 fg	10.64 g-j	25.9 f-i	23.2 a-e
CPM-860	55.3 ab	3.3 b	7.2 ab	77 e-g	87 a-c	129 d-f	11.41 d-i	29.2 b-d	21.3 f-h
Binasola-3	48.6 de	2.3 cd	6.2 d	76 gh	88 ab	124 l	11.32 d-i	26.3 e-i	23.2 a-e
Binasola-4	47.2 d-f	3.0 b	6.5 cd	76 gh	88 ab	125 kl	10.64 g-j	27.3 c-i	23.8 a-d

In a column figures having the same letter(s) do not differ significant at 5% level by DMRT

Table II. Variation in yield and yield attributes among 25 chickpea genotypes

Mutants/ lines/ varieties	Filled pods plant^{-1}	False pods plant^{-1}	Seeds pod^{-1}	100 seed weight (g)	Seed yield (g plant^{-1})	Seed yield (kg ha^{-1})
P-70	24.3 e-h	6.2 cd	1.3 ef	19.2 b	5.15 fg	1530 e-g
CPC-811	32.6 ab	4.8 fg	1.5 bc	15.5 cd	6.12 cd	1660 cd
CPC-814	34.3 a	5.1 e-g	1.5 bc	14.7 d	6.58 ab	1784 b
CPC-816	27.3 c-e	6.0 c-e	1.3 ef	15.5 cd	4.67 hi	1355 hi
CPC-818	25.3 d-g	6.2 cd	1.4 c-e	16.3 c	5.32 f	1570 d-f
CPC-820	20.6 hi	6.5 c	1.3 de	16.6 c	4.85 gh	1440 gh
CPC-821	18.0 ij	9.9 b	1.3 de	14.2 de	4.07 j	1193 k-n
CPC-823	23.3 eh	6.2 cd	1.3 de	12.6 gh	4.24 ij	1229 j-l
CPC-824	18.3 ij	10.2 b	1.5 bc	13.6 e-g	4.16 j	1089 no
CPC-825	25.6 d-g	5.7 c-f	1.6 ab	13.8 e-g	5.38 ef	1494 fg
CPC-826	22.0 g-i	9.7 b	1.3 ef	12.8 f-h	4.28 ij	1107 m-o
CPC-830	32.3 ab	4.4 g	1.7 a	16.2 c	6.96 a	1965 a
CPM-825 (gr)	32.0 ab	5.7 c-f	1.6 ab	12.6 f-h	5.56 ef	1660 cd
CPM-834	29.3 b-d	5.3 d-g	1.1 fg	22.3 a	6.35 bc	1690 bc
CPM-840	25.3 d-g	6.5 c	1.0 g	12.7 f-h	4.14 j	1155 l-n
CPM-841	21.6 g-i	6.7 c	1.1 fg	13.1 e-g	3.24 k	1140 l-n
CPM-846	22.3 f-i	6.5 c	1.5 bc	12.7 f-h	5.16 fg	1265 i-k
CPM-848	18.3 ij	10.5 b	1.1 fg	12.4 g-h	4.32 ij	1215 k-m
CPM-849	23.3 e-h	5.7 c-f	1.4 c-e	12.6 f-h	4.34 ij	1240 j-l
CPM-851	14.6 j	12.3 a	1.0 g	11.3 h	3.24 k	1017 o
CPM-855	23.6 e-h	6.5 c	1.6 ab	12.5 gh	5.25 fg	1330 ij
CPM-858	18.3 ij	9.9 b	1.1 fg	12.9 fg	4.43 h-j	1270 i-k
CPM-860	27.3 c-e	5.9 c-e	1.1 fg	21.1 a	5.78 de	1605 c-e
Binasola-3	26.6 c-f	5.7 c-f	1.3 de	14.5 de	4.68 hi	1370 hi
Binasola-4	30.6 a-c	5.9 c-e	1.5 bc	13.3 e-g	4.49 h-j	1520 e-g

In a column figures having the same letter(s) do not differ significant at 5% level by DMRT.

Chickpea mutants/lines, CPC-811, CPC-814, CPC-830 and CPM-860 produced higher number of secondary branches per plant ranging from 7.0 to 7.6 per plant; the highest being recorded in CPC-830 (Table I). In contrast 9 mutants/lines produced fewer secondary branches per plant ranging from 4.0 to 4.6 per plant and the lowest (4 plant^{-1}) was recorded in CPM-848. Result also revealed that high yielding genotypes, in general, produced higher number of secondary branches per plant. It means yield is positively correlated with secondary branches. High variability in the number of secondary branches of chickpea genotypes was also reported by Ahmad *et al.* (2003). The differential response of secondary branches number in the mutants could be attributed to their genetic potentiality.

Phenological characters. Days required to opening of first flower varied significantly among the studied mutants/lines/varieties. Of the studied mutants/lines, CPC-834 showed the earliest flowering (61 DAS), which was significantly different from the others. In contrast, the maximum days to flowering (83 DAS) were observed in CPM-814 (Table I).

Minimum days to 50% flowering (70 DAS) were observed in CPM-834 (Table I). On the other hand 10 mutants/lines viz. CPC-821, CPC 823, CPM-840, CPM-841, CPM-846, CPM-851, CPM-855, CPM-860, Binasola-3 and Binasola-4 took the more days to 50% flowering ranging from 87 to 89 DAS with the highest in CPM-841 (89DAS).

The mutant CPM-851 took maximum days to maturity (135 DAS) followed by CPC-824 (132 DAS). In contrast CPM-834 took minimum days to maturity (120 DAS) (Table I). Result further revealed that in general low yielding genotypes required more days to maturity than the high yielding ones. Which indicates seed yield in chickpea is negatively correlated with days required to maturity. Obaidullah *et al.* (2006) also reported that seed yield in chickpea was negatively correlated with days to maturity, which supported the present experimental results.

Physiological and biochemical characters. Total dry matter production of chickpea mutants/lines/varieties differed significantly. Results revealed that, high yielding genotypes produced higher TDM per plant compared to low yielding ones. Four mutants/lines viz. CPC-811, CPC-814, CPC-830 and CPM-834 produced higher (range 13.16-14.49 g) TDM per plant. In contrast CPM-849 and CPM-851 produced lower TDM per plan and the lowest (9.76 g) was recorded in CPM-851 (Table I). These two mutants also produced lower seed yield indicating that seed yield depend on TDM production. It was evident that some mutants showed higher and some other mutants showed lower TDM per plant than their mother Binasola-3, which reflected variability created in respect of TDM production due to physical mutagenesis. Total dry matter production depends on its canopy structure. A greater canopy occupied plant should have higher number of branches as well as leaves, which has capacity to capture more sunlight and produced maximum assimilates. The linesCPC-830, CPC-814 and CPC-834 obtained higher number of secondary branches and also produced higher TDM (Table I).

Harvest index reflects translocation or alternatively dry matter partitioning of a given genotype to the economic part. The lines CPC-830 (32.6%) and CPC-814 (30.3%) showed the highest and second highest harvest index despite showing significant difference between them (Table I). Again CPC-814 showed its rank with other mutants/lines such as CPC-811, CPC-825 (gr), CPM-834 and CPM-860. In contrastCPM-851 produced the lowest harvest index (20.6%) and showed indifference with CPM-840 (22.1%) and CPC-820 (22.4%). According to Jeena *et al.* (2005) high harvest index percent contribute to high yield. High yield is determined by physiological process leading to a high net accumulation to photosynthates and it's partitioning in to plant and seed.

Grain protein contents varied significantly among the studied mutants/lines/varieties. Out of twenty five, 11 mutants/lines showed higher protein content in grain ranging from 22.7% to 24.6% with similar statistical rank (Table I) and the highest was recorded in CPM-855 (24.6%). On the other hand, CPC-830 contained the lowest (18.7%) amount of protein in grain followed by P-70 (19.4%) with same statistical rank. All other mutants recorded intermediate protein content (range 20.5-22.6%). The variability in protein content in chickpea seed were also observed by Benu and Shrivastava (2006).

Yield and yield contributing characters. Filled pod number, the most important attribute had shown significant difference between the mutants/lines. CPC-814 produced the maximum filled pods per plant (34.3) followed by CPC-811, CPC-830, CPM-825(gr) and Binasola-4, whilst CPM-851 produced minimum number of filled pods followed by CPC-821, CPC-824, CPM-848 and CPM-858 (Table II). Likewise, maximum false pods per plant (12.3) were observed in CPM-851, which resulted fewer filled pods per plant. In contrast, higher filled pod producing genotypes produced fewer false pods per plant.

Number of seeds per pod varied significantly among the studied mutants/lines/varieties but had not shown wide range of variability (Table II). CPC-830 showed the highest number of seeds per pod (1.7) followed by CPC-825 (1.6), CPM-825 g (1.6) and CPM-855 (1.6) with same statistical rank. The other 7 mutants viz. CPM-834, CPM-840, CPM-841, CPM-848, CPM-851, CPM-858 and CPM-860 showed lower seed number per pod (rang 1.0-1.1) and the lowest was recorded in CPM 840 (1.0). Significant variability in seeds per pod in chickpea was also observed by Ahmad *et al.* (2003). Hundred seed weight showed a wide range of variability amongst the mutants/lines. Maximum 100-seed weight (22.3 g) was observed in CPM-834 that was difference from all other mutants/lines (Table II).

There was a remarkable difference for seed yield per plant amongst different genotypes (Table II). Maximum seed yield per plant (6.96 g) was observed in CPC-830, which was statistically similar to CPC-814 (6.58 g). These two lines produced higher seed yield due to production of higher pods per plant supported by the greater number of secondary branches per plant (Table I). The lowest seed yield per plant was recorded in CPM-851(3.24 g), which was significantly different from all other mutants/lines. The seed yield was the lowest in CPM-851 due to less number of filled pods and more number of false pods per plant as well as smaller seed size. Results also revealed that low yielding genotypes also produced lower number of secondary branches per plant (Table I). It was evident that some mutants showed higher and some mutants showed lower seed yield per plant than their mother, Binasola-3, which

Table III. Correlation co-efficient among yield and different yield attributes of 25 chickpea genotypes

Characters	Filled pods $plant^{-1}$	Seeds pod^{-1}	100 seed weight (g)	TDM (g $plant^{-1}$)	Plant height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Days to 1st flowering	Days to 50% flowering	Days to maturity	Protein content (%)	Harvest index (%)
Seed yield/ plant	0.882**	0.531**	0.564**	0.923**	0.783**	0.832**	0.857**	-0.531**	-0.558**	-0.430**	-0.392*	0.933**
Pods/ plant		0.481**	0.388*	0.499**	0.781**	0.850**	0.867**	-0.366*	-0.360*	-0.532**	-0.375*	0.827**
Seeds/ pod			0.180	0.499**	0.397*	0.386*	0.380*	0.009	-0.057	-0.054	0.563**	0.130
100 seed weight (g)				0.568**	0.530**	0.554**	0.623**	-0.468**	-0.486**	-0.326*	-0.605**	0.535**
TDM/ plant (g)					0.879**	0.868**	0.870**	-0.489**	-0.528**	-0.492**	-0.392*	0.933**

**, * indicate significant at 1% and 5% level of probability respectively

Table IV. Some qualitative characters of studied chickpea mutants/lines/varieties

Mutants/ lines/ varieties	Leaf color	Leaf size	Seed coat color	Seed size
P-70	Light green	Medium	Brownish	Bold
CPC-811	Light green	Small	Reddish	Medium
CPC-814	Light green	Medium	Brownish	Medium
CPC-816	Light green	Medium	Reddish	Medium
CPC-818	Green	Medium	Reddish	Medium
CPC-820	Light green	Medium	Reddish	Medium
CPC-821	Light green	Medium	Reddish	Medium
CPC-823	Light green	Medium	Reddish	Small
CPC-824	Light green	Medium	Reddish	Medium
CPC-825	Green	Large	Reddish	Medium
CPC-826	Green	Small	Reddish	Small
CPC-830	Green	Small	Reddish	Medium
CPM-825 (gr)	Deep green	Small	Greenish	Small
CPM-834	Green	Large	Reddish	Bold
CPM-840	Green	Medium	Brownish	Small
CPM-841	Light green	Medium	Brownish	Medium
CPM-846	Light green	Medium	Brownish	Small
CPM-848	Light green	Medium	Brownish	Small
CPM-849	Light green	Small	Brownish	Small
CPM-851	Green	Medium	Brownish	Small
CPM-855	Green	Medium	Brownish	Small
CPM-858	Green	Medium	Brownish	Small
CPM-860	Light green	Medium	Brownish	Bold
Binasola-3	Green	Small	Reddish	Medium
Binasola-4	Green	Small	Reddish	Medium

reflected that variability in respect of seed yield was created due to gamma mutagenesis. The variability occurred in seed yield due to gamma irradiation in chickpea was also reported by Santosh (2005).

Correlation between seed yield and yield attributes. The associations of different yield attributes has been assessed with yield and are presented in Table III. There was highly significant positive correlations of seed yield per plant with number of pods (r=0.88**), TDM (r=0.92**), plant height (r=0.78**), number of primary branches(r=0.83**) number of secondary branches (r=0.86**) number of seeds (r=0.53**), 100-seed weight (r=0.56**) and harvest index (r=0.93**). Moreover, seed yield was correlated negatively with days to flowering (r=-0.53**), days to 50% flowering(r=0.55**), days to maturity (r=-0.43**) and protein contents (r= 0.39*). These results indicated that a high yielding genotype should have taller plants with higher number of primary and secondary branches, which resulted production of higher number of pods per plant and ultimately yield. These results are consistent with the results of many workers in chickpea (Kumar *et al.* 2003; Ravel & Dobariya, 2003; Jeena *et al.*, 2005; Obaidullah *et al*., 2006).

Qualitative characters for key to identification. The qualitative characters of 25 chickpea mutants/lines/cultivars are presented in Table IV. Thirteen mutants/lines were light green, 11 were green and one were deep green in leaf colour out of all the entries, but they are not easily distinguishable at a glance. However, 15 genotypes were produced medium size leaflets, which were not easily separated by visual selection but two genotypes viz. CPM-834 and CPC-825 were large leaflet sized plants, which were easily differentiable from the others. For seed coat size the mutants/lines CPM-834, CPM-860 and P-70 were bold seeded, 7 mutants/lines were small seeded and rest 15 were medium seeded. In case of seed coat colour 10 mutants/lines had reddish and 14 had brownish seed coat colour. Only CPM-825 (gr) had distinct greenish seed coat colour. The key for identification of mutants based on vegetative and reproductive characters, results revealed that among the studied mutants/lines only CPM-825 (gr) had distinct greenish seed coat colour which could be used as maintained the purity of the developed chickpea mutants.

To conclude, the mutants/lines, CPC-814, CPC-830, CPM-825(gr) and CPM-834 may be selected for further trails on the basis of seed yield and early maturity characteristics.

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