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Harnessing Positive Variability in F_2 and M_2 Populations of Lentil

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Abstract

Lentil germplasm comprising of six F_2 and twenty M_2 populations was evaluated under field conditions to estimate genetic variability with the help of genetic parameters. The cross AEL23/40 x Precoz among all other combinations had higher estimates of coefficients of variability (PCV= 7027.59%, GCV= 7006.67%) and highest values of heritability (99.70%) and genetic advance (142.99) for pods per plant. The same cross had highest values of coefficients of variability (PCV= 568.31%, GCV= 540.69%), heritability (95.14%) and genetic advance (183.45%) for seed yield. Overall, the variability was less in 100 seed weight as compared to other traits under study. In M_2 population at 100 Gy, Masoor-85 exhibited greater than 50% GCV along with moderate value of genetic advance (30.33) for plant height. The genotypes 00518, 01512, 03501, Lentil black and Masoor 85 showed more than 50 % GCV, more than 90% heritability combined with moderate values of genetic advance for plant height at 150 Gy. Masoor-85 showed higher estimates of coefficients of variability (PCV= 4373.29%, GCV= 4235.51%), heritability (96.85%) and genetic advance (78.79%) followed by NL 96635 for pods/plant at 150 Gy. The genotypes 01512, NL 96635 and NL 96475B showed more than 90% heritability and genotypic coefficients of variability for seed yield whereas for 100 seed weight, the genotype Lentil Black had highest value of genotypic coefficient of variation (14.72%) with heritability of 93.04% combined with highest value of genetic advance (45.90%) among all the genotypes. In conclusion, crosses and mutant populations in both F_2 and M_2 populations showed greater genetic variability especially for pods/plant followed by seed yield and plant height. Hence diversified plants/lines can be expected in succeeding generations.

Keywords: Germplasm, genetic parameters, gamma irradiation, hybridization, variation
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Introduction

Lentil (*Lens culinaris* Medik.) is an important annually sown, cool season food legume crop which is cultivated worldwide as human food providing an important source of dietary protein. As a food it provides 26% protein (Verma *et al*. 1993). In addition to that, it restores the fertility of soil through biological nitrogen fixation and increases seed yield from 23-32% and straw yield up to 16% (Webb and Hawtin, 1981). It was first domesticated in Southern Turkey; from there it moved to Europe and Asia (Cubero, 1984).

In Pakistan lentil is the second major winter season pulse crop after chickpea and is grown on an area of 17.1 thousand hectares with a production of 8.1 thousand tons in 2014-15. Its production is declining continuously from the past decade and during 2014-15 it decreased by 5.8 percent (Anonymous, 2014-15). This continuous decreasing trend is due to many environmental and socio-economic factors which need to be addressed to cope with increased population and to cut short the import bill of the country. Low yield potential of existing varieties, susceptibility to diseases, narrow genetic base, abiotic stresses (cold, heat and drought) and weed infestation are the major factors for low productivity (Ali and Shaikh, 2007). The major cause in reduction of lentil area is the changing trend of farmers of shift towards major crops i.e. wheat and rice due to low productivity of lentil and heavy weed infestation.

Such problems of low productivity in lentil production can be solved through formulating an effective breeding program. The efficiency of any breeding program depends upon the amount of genetic variability within the available germplasm. Genetic variability can be created through many conventional and non-conventional techniques. Knowledge of inheritance pattern of genetic parameters is essential for successful breeding program. Burton (1952) suggested that the genotypic coefficient of variability should be considered with the heritability estimates. While Johnson *et al*. (1955) suggested that heritability estimates should be considered together with the genetic advance. Higher the genotypic coefficient of variation than phenotypic coefficient of variation, more the variation due to genotype and less influence of environment.

Keeping this in view, a breeding program was initiated at NIAB, Faisalabad for the creation of genetic variability through intraspecific hybridization

and induced mutations. And an attempt was made to estimate genetic variability with the help of genetic parameters such as phenotypic variance (Vp), phenotypic coefficient of variation (PCV), genotypic variance (Vg), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance (GA).

Materials and methods

The experimental material of F_2 population was obtained by making combination of 8 genotypes viz. NIAB Masoor 2002, AEL 23/40, Precoz, ILL6821, NARC 06-1, NL 96635, NL 96476 and 01505 of lentil during 2012 and raising of F_1 and F_2 during 2013 and 2014 respectively.

M_2 generation was raised during 2014 by planting seed of M_1 generation that was obtained by treating the seed of 10 genotypes viz. 00518, 01512, 03501, NARC 06-1, NL 96625, NL 96635, NL 96475B, NL 96680, Lentil Black and Masoor 85 with 100 and 150 Grey. Both F_2 and M_2 were planted side by side at experimental field of NIAB, Faisalabad. Observation on single plant basis for plant height, number of pods per plant, seed yield and 100 seed weight were recorded both in F_2 and M_2 generation. Data were statistically analyzed following Steel *et al*. (1997), Singh and Chaudhry (1985) and Allard (1966) and different genetic parameters like components of variance, heritability, genetic advance and coefficients of variation were estimated.

The genotypic variances in F_2 and M_2 populations were calculated by employing the following formulas.

$$\textbf{Vg of F2 Generation} = \frac{\textbf{Vp of F2 generation} - \textbf{Vp of P1} + \textbf{Vp of P2}}{\textbf{Vp of P1} + \textbf{Vp of P2}}$$

$$\textbf{Vg of M2 Generation} = \frac{\textbf{Vp of M2 generation} - \textbf{Vp of Parent}}{\textbf{Vp of Parent}}$$

Whereas, Vg; genotypic variance and Vp; phenotypic variance

Results and discussion

Genetic parameters of F_2 Populations

Genetic variability is a pre-requisite for successful breeding, especially in those characters for which improvement is required. Genetic parameters were computed for plant height, number of pods per plant, seed yield per plant and 100-seed weight. In F_2 generation (Table-1) the mean value of plant height ranged from 35.17 to 43.57 with an average of 38.39 cm. The phenotypic variance among different cross combinations ranged from 10.57 to 47.95 and genotypic from 8.23 to 46.12 with mean values of 28.54 and 25.49 respectively. Estimation of phenotypic coefficient of variation was ranged from 37.60 to 114.54 and genotypic coefficient from 23.41 to 105.85. Phenotypic coefficient of variation was high (114.54 %) in cross AEL23/40 x ILL 6821 followed by NL 96353 x Precoz (110.05%). Genotypic coefficient of variation was maximum in NL 96353 x Precoz (105.85 %) followed by AEL 23/40 x ILL 6821 (105.60 %).

In general, the estimates of genotypic coefficient of variation (GCV) were lower than the estimates of phenotypic coefficient of variation (PCV) for plant height in all cross combinations, which implies the influence of environment in the expression of trait. Similar results of higher phenotypic coefficient of variation for plant height were observed by Tyagi and Khan (2010), Ahmad and Tyagi (2010), Kumar *et al*. (2008), Makeen *et al*. 2007 and Abbas *et al*. 2005. The results were encouraging with respect to the heritability of the plant height for all crosses. Heritability was ranged from 76.88 to 96.18 % with an average of 86.02% and maximum value in cross NL 96353 x Precoz (96.18 %) followed by AEL 23/40 x ILL6821 (92.20%). Genetic advance ranged from 14.84 to 33.28 % with an average of 24.07%. Genetic advance for plant height was maximum in cross combination AEL 23/40 x ILL6821 followed by NL96353 x Precoz. High heritability estimates coupled with high genetic advance would be more rewarding than heritability alone because of additive types of genes (Jhonson *et al*. 1955). Similar results of high heritability and moderate genetic advance for plant height were observed by Younis *et al*. (2008).

Mean values of number of pods/plant in F_2 generation (Table-2) ranged from 145.00 to 271.57 pods per plant with an average number of 226.16 pods per plant. Maximum value of phenotypic variance (20107.90) and phenotypic coefficient of variation (8693.14%) was observed in cross combination AEL 23/40 x ILL6821. Similarly higher values of genotypic variance (19943.23) and genotypic coefficient of variation (8621.95) were observed in cross AEL 23/40 x ILL6821. It is evident from the results that this cross can be used efficiently for the improvement of lentil and more productive variants with higher number of pods can be selected for evolving high yielding genotypes. Heritability values ranged from 47.48 % to 99.76 % and genetic

advance from 23.69 to 142.99 %. Cross AEL 23/40 × Precoz had 99.70% heritability coupled with highest value of genetic advance (142.99%) followed by AEL 23/40 × ILL 6821 which had heritability value of 99.18% combined with genetic advance of 125.25%. The overall average values in respect of all genetic parameters were higher in pods/plant as compared to other traits of lentil crosses under study. Higher values of phenotypic coefficients of variability than genotypic coefficients of variability and for heritability and genetic advance are in agreement with the findings of Tyagi and Khan (2010), Kumar *et al*. (2008) and Punia *et al*. (2011).

Mean seed yield in all crosses ranged from 6.49 g to 10.89 g per plant with average value of 9.26 g (Table-3). The phenotypic variance ranged from 3.44 to 36.86 and genotypic variance from 2.52 to 35.07. Phenotypic coefficient of variation ranged from 38.33% to 568.31% and genotypic coefficient of variation from 25.77% to 540.69%. AEL 23/40 x Precoz showed higher variability as compared to other crosses and had higher estimates of heritability (95.14%) combined with highest value of genetic advance (183.45%). In this cross combination, seed yield seems to be controlled by additive genes, therefore, it can be exploited for the improvement of this trait in lentil. Overall, heritability values ranged from 25.59 % to 95.14 % with mean value of 74.25% and genetic advance from 16.92 to 183.45 % with an average of 67.31%. Higher estimates of heritability and genetic advance for seed yield were reported by Younis *et al*. (2008), Panse (1957) and Ashraf *et al*. (2008). Cross AEL 23/40 × ILL6821 had second highest values of coefficients of variability and genetic advance. The results are in conformation with the findings of Rasheed *et al*. (2008).

The range of mean with respect to 100 seed weight was from 1.94 g to 2.98 g in different crosses (Table-4). The phenotypic variance ranged from 0.02 to 0.09 and genotypic from 0.01 to 0.08. The range of phenotypic coefficient of variation was from 1.10% to 4.07% and that of genotypic coefficient of variation was from 0.31 % to 3.45 %. Heritability ranged from 12.38 % to 86.86 % and genetic advance from 2.75 % to 24.62 %. Sarwar *et al*. (2010) reported similar results of heritability and genetic advance for 100 seed weight. Cross AEL 23/40 × ILL 6821 had highest values of coefficients of variability (PCV= 4.07%, GCV= 3.54%), heritability (86.86%) and genetic advance (24.62%) for 100 seed weight followed by cross AEL 23/40 × precoz which had second highest values of coefficients of variability (PCV= 2.35%, GCV= 1.42%), heritability (60.18%) and genetic advance (24.62%). Hundred seed weight had lowest genetic advance, hence it cannot be fully exploited for improvement of lentil crop in this study.

Conclusively, the variability was less in 100 seed weight as compared to other traits under study. Overall, the cross AEL23/40 x Precoz had second higher estimates of coefficients of variability (PCV= 7027.59%, GCV= 7006.67%) and highest values of heritability (99.70%) and genetic advance (142.99) for pods per plant. The same cross had highest values of coefficients of variability (PCV= 568.31%, GCV= 540.69%), heritability (95.14%) and genetic advance (183.45%) for seed yield. Whereas the cross AEL 23/40 × ILL 6821 had higher estimates of coefficients of variability (PCV= 114.54%, GCV= 105.60%), heritability (92.20%) and genetic advance (33.28%) for plant height. The same cross had highest values of coefficients of variability (PCV= 4.07%, GCV= 3.54%), heritability (86.86%) and genetic advance (24.62%) for 100-Seed weight. Hence it is concluded that cross combination AEL23/40 x Precoz was more fruitful regarding traits like pods per plant (an important yield contributing character) and seed yield per plant. So, this cross combination could be used in future breeding programs for the improvement of lentil.

Genetic parameters of M_2 populations

By the estimation of genetic parameters, the effect of induced mutations on quantitative characters like plant height, number of pods per plant, seed yield per plant and 100 seed weight can be inferred. Mean plant height in M_2 population at 100 Gy ranged from 37.60 to 48.50 cm (Table-5). The range of phenotypic variance was from 3.88 to 58.67 and that of genotypic variance was from 2.88 to 36.33. The phenotypic coefficient of variation ranged from 8.79 % to 126.62 % and genotypic coefficient of variation from 6.53 % to 90.69 %. Heritability estimates ranged from 39.68 % to 97.08 % and genetic advance from 6.31 % to 30.33 %. Maximum variability was observed in Masoor 85 followed by NL 96635 and NL 96680 while minimum was observed in NL 96475B which indicates that 100 Gy radiation dose can provide more variability in Masoor-85, NL 96635 and NL 96680 as compared to other genotypes. At 150 Gy mean plant height ranged from 34.67 to 47.08 cm (Table-5).

Phenotypic variance ranged from 6.06 to 33.82 and genotypic variance from 1.72 to 31.49. The phenotypic coefficient of variation was in the range of 15.33 % to 96.15 % and that of genotypic coefficient of variation was from 3.70 % to 89.42 %. Heritability ranged from 7.24 % to 98.20 % and that of genetic advance from 1.55 % to 31.91 %. In general all the genotypes had higher estimates of phenotypic coefficients of variability than their genotypic coefficients of variability. Genotypes i.e. 00518, 01512, 03501, Lentil black and Masoor 85 showed more than 50 % genotypic coefficient of

variation. These genotypes also had higher estimates of heritability (more than 90%) combined with moderate values of genetic advance. Hence it can be concluded that these genotypes could produce more diverse mutants as compared to other genotypes. Singh *et al.* (2000) studied genetic parameters for different characters in two urdbean varieties after mutagenic treatments. They observed positive and negative shifts in mean for all the quantitative traits in both the cultivars. All the mutagenic treatments influenced the mean, range and CV values independently in both the varieties. However, the combinations of varying doses were found effective for causing induced genetic variability.

Number of pods per plant in M_2 population ranged from 205.20 to 313.14 at 100 Gy (Table-6). The range of phenotypic variance was from 979.20 to 7991.38 and that of genotypic variance from 162.87 to 7016.22. Phenotypic coefficient of variation ranged from 358.94 % to 3255.66 % and genotypic coefficient of variation from 59.70 % to 3085.75 %. The heritability ranged from 16.63 % to 97.69 % and genetic advance from 3.93 % to 73.02 %. More than 80% heritability was observed in all the genotypes except Lentil Black (16.63%), 03501 (66.05%) and NL 96680 (61.40%). All the genotypes had moderate to higher estimates of genetic advance except for Lentil Black. Masoor-85 had higher estimates of coefficients of variability (PCV=3255.66%, GCV=3085.75%), heritability (94.78%) and genetic advance (73.88%) followed by NARC 06-1 which had second higher estimates of genetic parameters. The mean range of pods per plant at 150 Gy was from 167.67 to 348.15 (Table-6).

Phenotypic variance ranged from 2093.66 to 12262.71 and genotypic variance ranged from 1913.16 to 12075.47. The range of phenotypic coefficient of variation was from 730.13 to 4373.29 % and genotypic coefficient of variation was from 667.19 to 4235.51 %. Heritability ranged from 60.97 to 99.52 % and genetic advance from 28.34 to 78.79 %. More than 70 % heritability was noted in all the genotypes except 03501 (60.97%) at 150 Gy for pods per plant. Again Masoor-85 had higher estimates of coefficients of variability (PCV= 4373.29%, GCV= 4235.51%), heritability (96.85%) and genetic advance (78.79%). NL 96635 had second higher estimates of coefficients of variability with highest value of heritability (99.52%) coupled with genetic advance of 64.86%. Overall, Masoor-85 had better response both at 100 and 150 Gy and may produce high yielding variants with more number of pods in succeeding generations. Wani and Khan (2006) studied genetic parameters in M_2 and M_3 generations in mungbean for pods per plant, the weight of 100 seeds (g) and seed yield per plant (g). Estimates of genetic parameters for the yield and its components were higher than the control in two generations.

Mean seed yield per plant ranged from 8.20 g to 16.23 g (Table-7) at 100 Gy. The phenotypic and genotypic variance at 100 Gy ranged from 3.38 to 18.77 and 0.55 to 14.69 respectively. Phenotypic coefficient of variation ranged from 29.33 to 170.81 % while genotypic coefficient of variation ranged from 4.78 to 115.80 %. Heritability ranged from 11.19 % to 99.48 % while genetic advance from 4.47% to 58.65 %. Genotype NL 96625 had highest estimates of genotypic coefficients of variation (115.80%) with higher value of heritability (88.78%) combined with highest value of genetic advance (58.65%) among all the genotypes. For seed yield per plant, the genotypes 01512, NL 96635 and NL 96475B had more than 90% heritability combined with moderate values of genetic advance which indicates that the variants of such genotypes might be high yielder in succeeding generation and can be used in the evolution of high yielding lentil varieties. At 150 Gy, mean seed yield ranged from 8.88 g to 15.68 g (Table-7).

Phenotypic variance ranged from 5.99 to 25.42 and genotypic variance from 1.85 to 15.97. Phenotypic coefficient of variation ranged from 54.62 % to 200.68 % and genotypic coefficient of variation from 14.20% to 146.27 %. Heritability ranged from 25.99 % to 99.79 % and genetic advance from 10.95 % to 82.15 %. Genotype NL 96475B had highest value of genotypic coefficients of variation (146.27%) with higher value of heritability (96.55%) coupled with highest value of genetic advance (82.15%) among all the genotypes at 150 Gy. The genotypes 01512, NL 96635 and NL 96475B had more than 90% heritability for seed yield and the same genotypes had higher values of genotypic coefficients of variability (more than 90%) at 150 Gy. Hence it can be concluded that the mutants of such three genotypes might gave better yielding segregates in succeeding generations that can be selected and used for the evolution of high yielding varieties. Waghmare and Mehra (2000) studied magnitude of genetic variability for economic traits in M_2 and M_3 generations and observed that grain yield per plant have higher genetic variability followed by number of pods per plant, number of seeds per pod and plant height in both the generations.

Mean 100 seed weight of all genotypes at 100 Gy ranged from 1.58 g to 3.15 g (Table-8). Phenotypic variance ranged from 0.0002 to 0.21 and genotypic from 0.0001 to 0.21. The range of phenotypic coefficient of variation was from 0.19 % to 9.02 % and that of genotypic coefficient of variation was from 0.15 % to 9.00 %. Heritability values ranged from 37.79 % to 99.81 % and genetic

advance from 4.66 % to 40.00 %. Masoor-85 again had highest estimates of coefficients of variation (PCV= 9.02 %, GCV= 9.00 %), heritability (99.81%) combined with genetic advance of 40.00 % followed by NL 96475B which had second higher estimates of coefficients of variation with more than 90% heritability combined with moderate value of genetic advance. At 150 Gy, mean 100 seed weight of all genotypes ranged from 1.84 g to 3.26 g (Table-8). Phenotypic variance ranged from 0.05 to 0.84 and genotypic variance from 0.04 to 0.41. The range of phenotypic coefficient of variation was from 1.79 % to 45.82 % and genotypic coefficient of variation from 1.62 % to 14.72 %. Heritability ranged from 40.93 % to 99.53 % and genetic advance from 11.66 % to 45.90 %. Most of the genotypes had higher values of heritability (more than 90%). The genotype Lentil Black had highest value of genotypic coefficient of variation (14.72%) with heritability of 93.04% combined with highest value of genetic advance (45.90%) among all the genotypes.

In both segregating populations of F_2 and M_2 generations, higher values of genotypic coefficient of variation were estimated for pods per plant followed by seed yield per plant as compared to plant height and 100 seed weight. The values of genotypic coefficient of variation were high for all traits in F_2 except 100 seed weight which were found to be higher in M_2 population either at 100 Gy or 150 Gy. Heritability values were high in F_2 for all traits except 100 seed weight. For 100 seed weight heritability values were higher in M_2 population as compared to F_2 population. Genetic advance was at par for plant height both in F_2 and M_2 generations. In F_2 generation, genetic advance was higher for pods per plant and seed yield per plant than M_2 generation. In M_2 generation, 100 seed weight had more values of genetic advance than F_2 generation. In all these cases where high heritability was coupled with high genetic advance indicated that these characters in particular genotype or cross combination are governed by additive type of genes (Johnson, 1955 and Sarwar *et al.,* 2010). For other attributes where only heritability was high may be controlled by non-additive genes (dominant or epistasis). From present results, it can be concluded that the traits like seed yield per plant and 100 seed weight had high heritability values along with high genetic advance in some genotypes/crosses which showed that these traits are controlled by additive genes while other traits i.e. plant height and pods per plant are controlled by non-additive genes.

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Table-1: Genetic Parameters for Plant Height in F_2 Generation of Lentil

Crosses (F2)	**Plant Height (cm)**						
	Mean	**Vp**	**PCV %**	**Vg**	**GCV %**	**h^2 %**	**G.A %**
AEL 23/40 × NIAB Masoor 2002	36.17	23.09	63.84	19.92	55.08	86.28	23.61
AEL 23/40 × ILL 6821	37.31	42.73	114.54	39.40	105.60	92.20	33.28
AEL 23/40 × Precoz	35.17	10.57	30.05	8.23	23.41	77.92	14.84
NL 96353 × Precoz	43.57	47.95	110.05	46.12	105.85	96.18	31.43
NARC 06-1 × NL 96476	39.75	32.50	81.76	28.17	70.86	86.67	25.60
01505 × NL 96476	38.35	14.42	37.60	11.09	28.91	76.88	15.68
Mean	38.39	28.54	72.97	25.49	64.95	86.02	24.07

Table-2: Genetic Parameters for Number of Pods per Plant in F_2 Generation of Lentil

Crosses (F2)	**No. of Pods/Plant**						
	Mean	**Vp**	**PCV %**	**Vg**	**GCV %**	**h^2 %**	**G.A %**
AEL 23/40 × NIAB Masoor 2002	242.61	7774.49	3204.51	7755.82	3196.81	99.76	74.69
AEL 23/40 × ILL 6821	231.31	20107.90	8693.14	19943.23	8621.95	99.18	125.25
AEL 23/40 × Precoz	145.00	10190.00	7027.59	10159.67	7006.67	99.70	142.99
NL 96353 × Precoz	219.57	2827.95	1287.94	1342.62	611.47	47.48	23.69
NARC 06-1 × NL 96476	246.88	11813.84	4785.35	9109.67	3689.99	77.11	69.94
01505 × NL 96476	271.57	6985.53	2572.32	4359.86	1605.46	62.41	39.57
Mean	226.16	9949.95	4595.14	8778.48	4122.06	80.94	79.35

Table-3: Genetic Parameters for Seed Yield in F_2 Generation of Lentil

Crosses (F2)	Seed Yield/Plant (g)						
	Mean	**Vp**	**PCV %**	**Vg**	**GCV %**	**h^2 %**	**G.A %**
AEL 23/40 × NIAB Masoor 2002	9.92	9.54	96.21	6.00	60.44	62.82	40.31
AEL 23/40 × ILL 6821	9.51	17.51	184.13	15.31	161.01	87.44	79.27
AEL 23/40 × Precoz	6.49	36.86	568.31	35.07	540.69	95.14	183.45
NL 96353 × Precoz	8.98	3.44	38.33	2.96	32.96	86.00	36.60
NARC 06-1 × NL 96476	9.78	9.85	100.72	2.52	25.77	25.59	16.92
01505 × NL 96476	10.89	7.98	73.33	7.07	64.89	88.50	47.31
Mean	9.26	14.20	176.84	11.49	147.63	74.25	67.31

Table-4: Genetic Parameters for 100-Seed Weight in F_2 Generation of Lentil

Crosses (F2)	100-Seed weight (g)						
	Mean	**Vp**	**PCV %**	**Vg**	**GCV %**	**h^2 %**	**G.A %**
AEL 23/40 × NIAB Masoor 2002	2.13	0.02	1.10	0.01	0.63	57.46	8.34
AEL 23/40 × ILL 6821	2.18	0.09	4.07	0.08	3.54	86.86	24.62
AEL 23/40 × Precoz	2.98	0.07	2.35	0.04	1.42	60.18	10.82
NL 96353 × Precoz	1.94	0.05	2.55	0.02	1.17	46.01	10.75
NARC 06-1 × NL 96476	2.13	0.05	2.46	0.01	0.31	12.38	2.75
01505 × NL 96476	2.18	0.06	2.71	0.01	0.45	16.81	3.81
Mean	2.26	0.06	2.54	0.03	1.25	46.62	10.18

Vp = Phenotypic Variance, PCV = Phenotypic Coefficient of Variation, Vg = Genotypic Variance, GCV = Genotypic Coefficient of Variation, h2 = Heritability, G.A = Genetic Advance.

Table-5: Genetic Parameters for Plant Height (cm) in M_2 Generation of Lentil

Genotype	Dose	Mean	Vp	PCV	Vg	GCV	h^2	G.A
00518'	100 Grey	41.14	16.53	40.17	14.20	34.50	85.88	17.48
01512'		48.50	17.10	35.26	16.60	34.23	97.08	17.05
03501'		40.07	14.23	35.50	11.89	29.68	83.60	16.21
NARC 06-1		43.40	22.80	52.53	20.47	47.16	89.77	20.34
NL 96625		42.00	10.50	25.00	4.17	9.92	39.68	6.31
NL 96635		46.33	58.67	126.62	36.33	78.42	61.93	21.09
NL 96475B		44.10	3.88	8.79	2.88	6.53	74.21	6.83
NL 96680		37.60	22.80	60.64	18.47	49.11	80.99	21.19
Lentil Black		39.80	9.20	23.12	6.87	17.25	74.64	11.72
M-85		39.25	37.93	96.63	35.60	90.69	93.85	30.33
00518'	150 Grey	43.56	30.42	69.84	28.09	64.49	92.33	24.08
01512'		42.50	27.73	65.24	27.23	64.06	98.20	25.06
03501'		38.93	31.30	80.41	28.97	74.42	92.55	27.40
NARC 06-1		45.33	9.00	19.85	6.67	14.71	74.07	10.10
NL 96625		40.91	8.49	20.76	2.16	5.27	25.41	3.73
NL 96635		47.08	24.08	51.14	1.74	3.70	7.24	1.55
NL 96475B		45.20	18.70	41.37	17.70	39.16	94.65	18.65
NL 96680		39.50	6.06	15.33	1.72	4.36	28.44	3.65

Lentil Black	34.67	33.33	96.15	31.00	89.42	93.00	31.91
M-85	46.60	33.82	72.58	31.49	67.57	93.10	23.94

Table-6: Genetic Parameters for Number of Pods per Plant in M_2 Generation of Lentil

Genotype	Dose	Mean	Vp	PCV	Vg	GCV	h^2	G.A
00518'	100 Grey	273.57	2806.66	1025.93	2705.32	988.89	96.39	38.45
01512'		274.00	2194.40	800.88	2013.90	735.00	91.77	32.32
03501'		313.14	4492.29	1434.58	2967.29	947.58	66.05	29.12
NARC 06-1		205.20	5747.20	2800.78	5513.87	2687.07	95.94	73.02
NL 96625		270.00	7991.38	2959.77	6791.04	2515.20	84.98	57.96
NL 96635		281.17	2525.77	898.32	2467.43	877.57	97.69	35.97
NL 96475B		238.80	1699.07	711.50	1626.07	680.93	95.70	34.03
NL 96680		244.00	4642.50	1902.66	2850.50	1168.24	61.40	35.32
Lentil Black		272.80	979.20	358.94	162.87	59.70	16.63	3.93
M-85		227.38	7402.55	3255.66	7016.22	3085.75	94.78	73.88
00518'	150 Grey	271.52	4695.93	1729.50	4594.59	1692.17	97.84	50.87
01512'		286.75	2093.66	730.13	1913.16	667.19	91.38	30.04
03501'		277.00	3907.38	1410.61	2382.38	860.07	60.97	28.34
NARC 06-1		220.33	5989.75	2718.49	5756.42	2612.59	96.10	69.54
NL 96625		212.00	4358.40	2055.85	3158.07	1489.65	72.46	46.48
NL 96635		348.15	12133.81	3485.19	12075.47	3468.43	99.52	64.86
NL 96475B		198.00	3657.50	1847.22	3584.50	1810.35	98.00	61.66
NL 96680		277.20	7283.73	2627.61	5491.73	1981.14	75.40	47.82
Lentil Black		167.67	4846.33	2890.46	4030.00	2403.58	83.16	71.12
M-85		280.40	12262.71	4373.29	11876.38	4235.51	96.85	78.79

Table-7: Genetic Parameters for Seed Yield per Plant (g) in M_2 Generation of Lentil

Genotype	Dose	Mean	Vp	PCV	Vg	GCV	h2	G.A
00518'	100 Grey	11.15	10.50	94.16	3.17	28.38	30.14	18.04
01512'		11.14	4.62	41.46	4.59	41.24	99.48	39.54
03501'		14.18	18.13	127.85	13.11	92.47	72.33	44.74
NARC 06-1		8.20	3.78	46.12	1.47	17.87	38.75	18.93
NL 96625		12.68	16.54	130.44	14.69	115.80	88.78	58.65
NL 96635		16.23	10.66	65.69	9.93	61.17	93.12	38.59
NL 96475B		12.41	5.77	46.51	5.31	42.78	91.97	36.68
NL 96680		12.58	5.94	47.25	0.66	5.29	11.19	4.47
Lentil Black		11.53	3.38	29.33	0.55	4.78	16.31	5.36
M-85		10.99	18.77	170.81	9.33	84.86	49.68	40.34
00518'	150 Grey	12.05	13.53	112.28	6.19	51.39	45.77	28.78
01512'		12.31	11.70	95.04	11.67	94.84	99.79	57.13
03501'		12.50	9.41	75.24	4.39	35.13	46.69	23.59
NARC 06-1		10.22	11.30	110.57	8.98	87.91	79.50	53.88
NL 96625		10.53	5.99	56.88	4.13	39.24	69.00	33.04
NL 96635		15.68	13.75	87.67	13.02	82.99	94.66	46.11
NL 96475B		8.88	13.45	151.49	12.99	146.27	96.55	82.15
NL 96680		13.05	7.13	54.62	1.85	14.20	25.99	10.95
Lentil Black		9.14	7.85	85.87	5.01	54.88	63.91	40.36
M-85		12.67	25.42	200.68	15.97	126.10	62.84	51.52

Table-8: Genetic Parameters for 100-Seed Weight (g) in M_2 Generation of Lentil

Genotype	Dose	Mean	Vp	PCV	Vg	GCV	h2	G.A
00518'	100 Grey	1.58	0.05	3.24	0.04	2.59	80.18	23.64
01512'		2.73	0.01	0.44	0.01	0.32	73.21	6.05
03501'		2.33	0.11	4.58	0.05	2.11	46.07	13.29
NARC 06-1		2.34	0.02	0.65	0.01	0.43	65.97	7.19
NL 96625		2.79	0.05	1.82	0.02	0.69	37.79	6.29
NL 96635		2.66	0.09	3.25	0.09	3.22	98.92	22.54
NL 96475B		3.15	0.18	5.56	0.17	5.38	96.73	26.45
NL 96680		2.34	0.00	0.19	0.00	0.15	79.17	4.66
Lentil Black		2.57	0.11	4.31	0.08	3.13	72.54	19.36
M-85		2.38	0.21	9.02	0.21	9.00	99.81	40.00
00518'	150 Grey	1.84	0.84	45.82	0.07	3.80	87.98	28.61
01512'		2.63	0.18	6.78	0.18	6.65	98.21	32.45
03501'		2.26	0.10	4.32	0.04	1.77	40.93	11.66
NARC 06-1		2.23	0.05	2.25	0.05	2.02	89.64	18.55
NL 96625		2.91	0.09	3.20	0.06	2.11	66.04	14.28
NL 96635		2.54	0.08	2.95	0.07	2.91	98.76	21.90
NL 96475B		3.26	0.06	1.79	0.05	1.62	90.20	13.77
NL 96680		2.29	0.21	9.18	0.21	9.14	99.56	41.09
Lentil Black		2.76	0.44	15.83	0.41	14.72	93.04	45.90
M-85		2.60	0.08	3.27	0.08	3.25	99.53	23.00