ISSN 2250-3153

Effect of mutagens on quantitative characters in M_2 and M_3 generation of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc)

Bolbhat Sadashiv N.[1] and Dhumal Kondiram N.[2]

[*] Department of Botany, Dada Patil Mahavidyalaya, Karjat, Dist- Ahmednagar-414402 (M.S.), India
[**] Department of Botany, University of Pune, Pune-411007 (M.S.) India

Abstract- The seeds of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc) cv. *Dapoli Kulthi*- 1 were subjected to gamma radiation (100, 200, 300 and 400Gy), EMS (0.2, 0.3, 0.4 and 0.5 %) and combination treatments. The mutations affecting gross morphological changes in growth and yield characters such as plant habit, flowering, pod morphology, maturity and seed yield were scored as quantitative characters. The micromutations at the population level can be easily detected in the form of increased variations for quantitative traits in the segregation of mutagen treated populations. Micromutations can alter morphophysiological characters hence they are of a particular interest to the plant breeders. Both the mutagens, gamma radiations and EMS proved to be very effective to induce variability in quantitative traits like plant height, primary branches per plant, days required for first flowering and first pod maturity, number of pods per plant, pod length, number of seeds per pod, 1000 seed weight and yield per plant in M2 and M3 generations. In present investigation positive as well as negative impact on quantitative traits was recorded.

Index Terms- Horsegram, Micromutations, Mutagens, Variability

I. INTRODUCTION

Horsegram (*Macrotyloma uniflorum* (Lam.) Verdc), Syn: *Dolichos biflorus* (L.) locally known as *hulga* or *kulthi* is one of the important minor, rainfed pulse crops of Maharashtra. It is drought tolerant and having good nitrogen fixing ability, but receives a low priority in cropping system, soil types etc. In addition to the protein supplement in human diet, it has medicinal value. It also furnishes concentrated feed for cattle and domestic animals. It is grown both in *kharif* and *rabbi* seasons as main crop, or as a mixed crop with tur, bajra or finger millet.

Horsegram originated and domesticated in the Indian subcontinent (Nene, 2006) which is native of the Old World Tropics. It is cultivated as a low-grade pulse crop in southern Asia, mainly from India to Myanmar. It is also grown as a forage and green manure in many tropical countries, especially in Australia and South-East Asia.

Verdcourt (1970) put horsegram under *Macrotyloma uniflorum* (Shambulingappa and Vishwanatha, 1990). Horsegram, the self pollinated crop, belongs to Fabaceae which is an annual herb, stem erect and branched, leaves alternate, petiolate, stipulate, trifoliolate, axillary inflorescence, flowers bracteate, bisexual, corolla papilionaceous with cream, yellow or greenish yellow colour, stamens 10, 9 fused and 1 free, ovary superior, 1-celled. Fruit-pod, curved towards apex, 5–8-seeded. Seeds oblong or rounded, pale to dark reddish brown or reddish black and orange-brown.

Horsegram is cultivated in areas with annual rainfall 300-600 mm and highly drought tolerant, but does not tolerate flooding or water logging. The favourable average temperature is 18 to 27ºC. Horsegram is adapted to a wide range of well-drained soils from sands and gravels to clay loams and heavy clays with neutral soils. It grows on soils having pH 5.5 to 8. (Bolbhat, 2011). Horsegram is relatively free from diseases and pests, but occasionally suffers from powdery mildew (*Sphaerotheca fuliginea*) and leaf spot (*Cercospora dolichi*) in high humid conditions. Yellow mosaic virus is one of the major constraints for its cultivation in peninsular India. In high rainfall conditions, leaf spot caused by *Ascochyta* sp. and web blight (*Thanatephorus cucumeris*) cause severe damage. Seed yield is also reduced by pod rot during late season rains, pod borers, and rodents (Barnabas et al., 2010 and Bolbhat, 2011).

II. MATERIALS AND METHODS

The authentic seeds of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc) cultivar Dapoli Kulthi-1 were obtained from Head, Department of Botany, College of Agriculture, Dr. Balasaheb Savant Konkan Krishi Vidyapeeth, Dapoli, Dist-Ratnagiri (M.S.) India. Gamma rays, ethyl methane sulphonate (EMS) and their combinations were employed in present study for the treatments of seeds of horsegram. Gamma radiation from ^{60}Co source fixed in the gamma cell 200 installed at Bhabha Automic Research Center (BARC), Trombay, Mumbai (MS) was used in the present work. Healthy, dry and uniform seeds of horsegram with moisture content of 10-12 % were treated with 100, 200, 300 and 400Gy. Ethyl methane sulphonate (Sigma chemical Co. Ltd. USA) was used for the seed treatment of horsegram. Various concentrations of EMS (0.2% to 0.5%) were prepared in 0.1M phosphate buffer pH-7.0 (Gichner *et al*., 1994). Selected seeds were soaked in distilled water for 10 hours and the wet seeds were treated with different concentrations of EMS (such as 0.2, 0.3, 0.4 and 0.5% v/v) for four hours. For combination treatments the gamma irradiated seeds were treated with different concentrations of EMS. The untreated seeds served as control. The seeds treated with various concentrations of EMS were washed thoroughly with tap water for two hours to

terminate the reaction of chemical mutagen and to leach out the residual chemicals. The treated seeds (675) from each treatment were used for raising M_1 generation in field. Present investigation was carried out at Department of Botany, University of Pune, Pune- 411 007 (M.S.). All the experiments were carried out in triplicate following RBD design. The distance between two rows and two plants was 30 X 15 cm and the distance between two adjacent plots was one meter. The seeds of individually harvested M_1 plants were sown in the experimental field to raise M_2 generation in separate rows during kharif season of the year 2008.

The treated as well as control plants were screened for quantitative traits to study the induced variability. From each replication and treatment including control 20 plants were randomly selected for recording data on different quantitative characters in M_2 generations. Data on nine quantitative traits such as plant height (cm), primary branches/plant, DAS for first flowering, DAS for first pod maturity, No. of pods/plant, pod length (cm), no. of seeds/pod, 1000 seed weight (g) and seed yield/plant (g) were recorded.

All the surviving M_2 plants were harvested individually and seeds of single plant from each treatment were kept separately for raising M_3 generation. Observations on quantitative characters in M_3 generation were similar to that of M_2 generation. Data on following nine quantitative traits were recorded.

Plant height: The height of each randomly selected plant was measured before harvesting from soil level of the plant to apex by using thread and scale. The average of 20 plants was recorded in tables.

Number of primary branches per plant: It was counted actually at maturity from randomly selected 20 plants and the average values were recorded in table.

Number of days required for first flowering: The number of days required for opening of first floral bud on the plant from sowing was recorded.

Number of days required for first pod maturity: The number of days required for maturity of first pod were noted.

Total number pods per plant: Total number of pods on each selected plant was counted and average was noted.

Pod length: The length of each pod was measured in by keeping the pod on scale and average values were recorded.

Number of seeds per pod: Total number of seeds per pod was calculated after harvesting and the average number of seeds per pod was recorded in table.

1000 seed weight: The weight of 1000 seeds was determined on fine chemical balance and average value was noted.

Total seed yield per plant: The total pods on each plant at maturity were harvested separately and the seeds were taken out. The weight of total seeds per plant was recorded and average values were considered to record in the tables.

Statistical Analysis : The data were summarized as the means of three replicates with standard deviation as the measures of variability. One-way ANOVA test was performed to determine significant differences due to various treatments. Fisher's LSD (Least significant difference) was used as post hoc test to as certain significant differences among treatments at p= 0.05. Statistical analysis and graphical data presentations were carried out by using Sigma stat (ver.3.5).

III. RESULTS AND DISCUSSION

Quantitative characters (Micromutations) in M_2 and M_3 generations

Gamma radiations and EMS proved to be very effective to induce variability in quantitative traits in M_2 and M_3 generations (Table-1 and 2).

Positive as well as negative impact on quantitative traits was well documented by Waghmare and Mehra (2000) in grass pea, Apparao et al., (2005) and Barshile et al., (2008) in chickpea, Bolbhat and Dhumal (2010), Dhumal and Bolbhat (2012) and Kanaka (2012) in horsegram.

Plant height

All the mutagens were effective for inducing variability in plant height (Table-1 and 2). Gamma radiation treatments have caused significant reduction in plant height. The minimum plant height 35.40cm was noted in 100Gy as compared to control (46.70 cm). EMS (0.2%) showed significant increase in plant height while other treatments showed –ve influene. Maximum and minimum plant height (53.60 cm and 38.20 cm) in M_2 generation had been recorded in 0.2% and 0.4%EMS. The average height of control plants was 46.70 cm.

The results obtained on effect of combination treatments on plant height in M_2 generation revealed that, there was no definite pattern. The highest (47.50cm) and lowest (25.70 cm) plant height as compared to control (46.70 cm) was noted in 400Gy + 0.5%EMS and 200Gy + 0.3%EMS.

Similar trend for plant height was observed in M_3 generation (Table-2). Maximum plant height (49.85cm, 49.32cm and 50.94cm in M_3 generation was recorded in 300Gy, 0.3%EMS and 300Gy +0.2%EMS respectively. The minimum plant height 44.57cm, 46.82cm and 41.84cm was noted in 200Gy, 0.5%EMS and 400Gy +0.3%EMS respectively. The average height of control plants was 50.99 cm.

All the doses/ conc. of gamma radiation, EMS, and their combinations caused reduction in plant height with few exceptions. Results reported by Dalvi (1990) and Nawale (2004) in horsegram and cowpea were in confirmatory with the present investigation. Reduction in plant height was noted by Gunsekaran et al., (1998), Khanna (1988), Khan et al., (2004) and Gaikawad et al., (2005) in cowpea, chickpea, mungbean and lentil respectively. Lower concentrations of EMS exerted a stimulatory effect on plant height. Findings of Yaqoob and Abdur (2001) in mungbean, and Barshile et al., (2008) in chickpea were in agreement with above results.

Number of primary branches per plant

Data obtained in M_2 generation on number of primary branches per plant (Table-1) indicated that the mean values of this parameter showed positive and negative influence. 300Gy and 0.3%EMS showed increased number of primary branches per plant. Maximum number of primary branches per plant was recorded in 300Gy (7.66) and 0.3%EMS (7.33) over control (6.30). In combination treatments there was no definite pattern. The maximum decrease (5.10) was noted in 100Gy + 0.5%EMS

as compared to control (6.30). The highest increase (9.10) was noted in 300Gy + 0.5%EMS. In majority of treatments the primary branches per plant were increased over control.

Similar trend was obtained in M_3 generation (Table-2). All the treatments showed increase in number of primary branches per plant as compared to control and M_2. Maximum number of primary branches was recorded in 100Gy (12.58), 0.2%EMS (10.73) and 200Gy + 0.2 %EMS (11.25) over control (10.99).

Almost all the treatments of gamma radiation and EMS showed positive as well as negative impact on primary branches per plant in horsegram. Dalvi (1990), Apparao et al., (2005), Sing et al., (2000), Nawale (2004) and Lawhale (1982) also noted similar trend with physical as well as chemical mutagens.

Number of days required for first flowering

The data recorded in Table-1 revealed that some treatments were stimulatory, while others were inhibitory to induce flowering in M_2 generation. The results on the gamma radiation treatments and EMS indicated that there was no significant change in number of days required for first flowering, while in combination treatments there was no definite pattern. The minimum number of days required for first flowering were (33.80 DAS), in 400Gy + 0.4%EMS as compared to control (53.30 DAS). In all the combination treatments, days to first flowering were less than control except 300Gy with different concentrations of EMS and 400Gy + 0.3%EMS.

Similar was the pattern noted for M_3 generation (Table-2). The minimum days required for first flowering were 50.98 DAS in 300Gy, 51.73 DAS in 0.2%EMS and 42.34 DAS in 400Gy + 0.4%EMS.

The number of days required for first flowering was not very much changed as compared to control except few treatments. However gamma radiation and EMS treatments caused slight delay with increasing dose/conc. of mutagens. Dalvi (1990) also noted similar results in horsegram with different mutagens. The results recorded by Gaikawad et al., (2005), Rudraswami et al., (2006), Manjaya and Nandanvar (2007), Ahire (2008) and Tambe (2009) in different legumes were supportive to the present findings.

Number of days required for first pod maturity

The data recorded in (Table-1) indicated that all the treatments of GR, EMS and their combinations had succeeded in reducing the duration for 1st pod maturity as compared to control. The results of combination treatments were highly significant for reducing the number of days required for 1st pod maturity. The minimum number of days (57.70 DAS) required for first pod maturity was noted in 400Gy + 0.4%EMS.

The data obtained for M_3 generation was on par with of M_2 generation (Table-2). Minimum days required for the first pod maturity were 79.17 DAS in 300Gy, 80.53 in 0.2% EMS and 71.14 DAS in 400Gy + 0.4 EMS as compared to control (83.00 DAS).

Gamma radiation (200Gy) was successful to induce earlier first pod maturity by about 5-6 days as compared to control. Nawale (2004) and Sing *et al*., (2000) reported contradictory findings with reference to this parameter. All the treatments of EMS and GR + EMS, caused reduction in number of days required for first pod maturity than control (except 0.4% EMS).

Number of pods per plant

Gamma radiation and EMS single and in combination had induced variability in number of pods per plant in M_2 generation. The data recorded in Table-1 revealed that the treatments had stimulatory as well as inhibitory effect. In M_2 generation maximum number of pods per plant (83.80) were noted in 300Gy and 0.2%EMS (93.80) than control (71.20). The minimum number of pods per plant (59.50) were recorded at 200Gy and (33.40) at 0.4%EMS as compared to control. However all the combination treatments have caused reduction in number of pods per plant except 300Gy + 0.5%EMS and 400Gy + 0.5%EMS.

The trend in variation of pod number observed in M_3 generation was similar to that of M_2 generation. M_3 generation had shown slight increase in pod number as compared to M_2 generation (Table-2). Maximum pods were recorded in 300Gy (110.32), 0.2 %EMS (107.82) and 400Gy + 0.2 %EMS (102.18).

There was increase as well as decrease in number of pods per plant with different doses/ concs. used. The results of Dalvi (1990) for horsegram were in agreement with the present study. Nawale (2004) in cowpea, Gaikawad et al., (2005) in lentil and Apparao et al., (2005) in chickpea noted similar results. However decrease in pod number was also recorded by Barshile et al., (2008) in chickpea.

Pod length

The treatments of GR, EMS and their combinations in M_2 as well as in M_3 did not show any change in pod length (Table-1 and 2).

All the mutagenic treatments showed inhibitory effect on pod length (except few). The results reported by Singh and Raghuvanshi (1985) and Singh et al., (2000) in *Vigna*, Tambe (2009) in soybean and Dalvi (1990) in horsegram were inconformity with present findings.

Total number of seeds per pod

Data on total number of seeds per pod (Table-1) in M_2 progeny showed non significant change as compared to control. M_3 generation showed similar trend (Table- 2). The results recorded in table, indicated that all the treatments of mutagens of GR, EMS and GR + EMS exerted inhibitory effects on number of seeds per pod except 400Gy, 0.3%EMS, 200Gy + 0.2%EMS and 200Gy + 0.4%EMS. Decrease in number of seeds per pod was recorded in chickpea, lentil, cowpea, green gram and horsegram by Barshile, (2006), Apparao et al., (2005), Gaikawad et al., (2005), Vandana and Dubey (1990), Nawale, (2004) and Dalvi (1990) respectively.

1000- Seed weight

Results recorded on 1000-seed weight (Table-1) indicated that all the treatments of GR and EMS had exercised negligible -ve effect on this parameter. But the combination treatments such as 300Gy + 0.4%EMS and 300Gy + 0.5%EMS (30.50g and 29.80g) had shown considerable increase in 1000 seed weight. The results of M_3 generation were on par with M_2 generation.

The results with GR, EMS and GR + EMS showed negative as well as positive impact in horsegram. Similar observations were also made by Apparao et al., (2005) in chickpea, Gaikawad et al., (2005) in lentil, Sagade (2008) and Sing et al., (2000) in urdbean and Tambe (2009) in soybean

Seed yield per plant

Mean values for seed yield per plant decreased in all treatments as compared to controls (Table-1). All the mutagenic treatments of gamma radiation except 300Gy showed –ve effect. The maximum seed yield (16.76g) was noted in 300Gy and minimum (11.22g) in 200Gy as compared to control (14.54g). EMS (0.2%) caused maximum increase (16.45g), while all other treatments showed reduction in seed yield per plant over control. The combination treatment 300Gy + 0.5%EMS had induced maximum increase (16.01g) over control (14.54g). But all other treatments had caused reduction as compared to control. In M_3 generation seed yield per plant was increased in all gamma radiation treatments, but it decreased in EMS and their combinations as compared to control (Table-2). But all M_3 population showed positive influence on total seed yield per plant as compared to M_2 population. Maximum total seed yield was recorded in 300Gy (19.60g), 0.2%EMS (16.34g) and in 200Gy + 0.4%EMS (16.96g) as compared to control (16.58g).

All the mutagenic treatments except few treatments showed inhibitory effect on seed yield per plant. Patil et al., (2004) in soybean, Auti (2005) in mungbean, Banu et al., (2005) in cowpea and Barshile et al., (2008) in chickpea also recorded adverse effect on seed yield per plant due to various types of mutagenic treatments. Hakande (1992) reported wider variability in yield due to mutagenic treatments in winged bean which was attributed to pollen sterility and genetical as well as physiological alterations caused by mutagens.

Yield is an important trait, as it governs the economic benefit. Its expression is inherited by many genes, which control the production, transport and storage of assimilates. Previous studies indicated that both additive and non-additive genes contribute to yield. Luthra et al., (1979), Reddy and Sree Ramulu (1982) also supported the above view. The variability in yield was induced by mutagenic treatments. In the present study increased seed yield was attributed to increase in number of pods per plant, length of pod, and 1000 seed weight per plant.

IV. CONCLUSION

Both the mutagens proved to be very effective to induce variability in quantitative traits like plant height, primary branches per plant, number of days required for first flowering and first pod maturity, number of pods per plant, pod length, number of seeds per pod, 1000 seed weight and yield per plant in M_2 and M_3 generations.

REFERENCES

[1] Ahire, D.D., "Isolation and characterization of induced mutants for morphological and agronomic traits and oil quality in soybean (*Glycine max* (L.) Merrill)", 2008, Ph.D. Thesis, University of Pune, Pune (MS), India.

[2] Apparao, B.J., Dalve, S.C., Auti, S.G. and Barshile, J.D., "Study of induced mutagenic variability in yield component of chickpea (*Cicer arietinum* L.) employing SA, EMS and gamma rays", 2005, Proc. Nati. Conf. in Plant Sci., Pravaranagar. M.S. India, 204-209.

[3] Auti, S.G., "Mutational Studies in mung (*Vigna radiata* (L.) Wilczek)", 2005, Ph.D. Thesis, University of Pune, Pune (MS), India.

[4] Banu, M.R., Kalamani, A., Ashok, S. and Makesh, S., "Effect of mutagenic treatments on quantitative characters in M_1 generation of cowpea (*Vigna unguiculata* (L.) Walp)", *Ad. Plant Sci.*, 2005, 18 (2): 505-510.

[5] Barnabas, A.D, Radhakrishnan, G.K. and Ramakrishnan U., "Characterization of a begomovirus causing horsegram yellow mosaic disease in India", *Eur J Plant Pathol*., 2010, 127:41–51.

[6] Barshile, J.D., Auti, S.G., Sagade, A.B. and Apparao, B.J., "Induced genetic variability for yield contributing traits in chickpea (*Cicer arietinum* L.) employing EMS, SA and GR", *Ad. Plant Sci.*, 2008, 21 (2): 663-667

[7] Bolbhat, S.N. and Dhumal, K.N. "Desirable mutants for pod and maturity characteristics in M_2 generation of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc)", *Res. on Crops*, 2010, 11 (2): 437-440.

[8] Bolbhat, S.N. "Studies on induced mutations in horsegram (*Macrotyloma uniflorum* (Lam.) Verdc)", 2011, Ph. D. Thesis, University of Pune, Pune (MS) India.

[9] Dalvi, V.V., "Gamma rays induced mutagenesis in horsegram (*Macrotyloma uniflorum* (Lam.)" Verdc), 1990, M.Sc. (Agri) Thesis, Dr. B. S. K. K. Vidyapeeth, Dapoli (MS), India.

[10] Dhumal, K.N. and Bolbhat, S.N., "Induction of genetic variability with gamma radiation and its applications in improvement of horsegram" in *Gamma Radiation*, 1st ed., Feriz Adrovic, Ed., Rijeca (Croatia): In Tech Publisher, 2012. Chapter 10, pp. 207-228.

[11] Gaikawad, N.B., Wadikar, M.S., Kamble, S.S. and Kothekar, V.S., "Induced macromutations in *Lens culinaris* Medic", 2005, Proc. Nati. Conf. in Plant Sci., Pravaranagar. M.S. India, 424-427.

[12] Gunasekaran, M., Selvaraj, U. and Raveendran, T.S., "Induced polygenic mutations in cowpea (*Vigna unguiculata* (L.) Walp)", *South Ind. Hort*., 1998, 46 (1-2): 13-17.

[13] Hakande, T.P., "Cytological studies in *Psophocarpus tetragonolobus* L.D.C", 1992, Ph.D. Thesis, Marathwada University, Aurangabad (MS) India.

[14] Kanaka, K.D., "Variability and divergence in horsegram (*Dolichos uniflorus*)", *J. Arid Land*., 2012, 4 (1): 71-76.

[15] Khan, S., Wani, M.R., Bhat, M. and Kouser, P., "Induction of morphological mutants in chickpea". *International chickpea and pigeonpea newsletter*, 2004, 6: 11.

[16] Khanna, V.K., "Effect of gamma irradiation of seeds on nucleic acid and ribonucleic activity in chickpea seedling". *International chickpea Newsletter*, 1988, 18:8-10.

[17] Lawhale, A.D., "Note on genetic variability in quantitative characters of cowpea in the M_3 generation", *Indian J. of Agric. Sci.*, 1982, 52 (1): 22-23.

[18] Luthra, O.P., Arora, N.D., Singh, R.K. and Chaudhary, B.D., "Genetics analysis for metric traits in mungbean (*Vigna radiata* L. Wilczek)", *Haryana Agricultural University Journal of Research*, 1979, 9: 19-24.

[19] Manjaya, J.G. and Nandanwar, R. S., "Genetic improvement of soybean variety JS 80-21 through induced mutations", *Plant Mutation Reports*, 2007, 1 (3):36-40.

[20] Nawale, S.R. "Studies on induced mutagenesis in cowpea (*Vigna unguiculata* (L.) Walp.)" 2004, M.Sc. (Agri) Thesis, Dr.B.S.K.K. Vidyapeeth, Dapoli (MS), India.

[21] Nene, Y.L., "Indian pulses through the millennia", *Asian Agri-History*, 2006, 10 (3): 179–202.

[22] Patil, A., Taware, S.P. and Raut, V.M., "Induced variation in quantitative traits due to physical (g-rays), chemical (EMS) and combined mutagen treatment in soybean (*Glycine max* (L.) Merrill)", *Soyb Genet Newsl*., 2004, 31: 1-6.

[23] Reddy, P.R. and Sree Ramulu, R.C. "Heterosis and combining ability for yield and its components in greengram (*Vigna radiata* (L.) Wilczek)", *Genetica Agraria*, (1982). 36: 297-308.

[24] Rudraswami, P., Vishwanatha, K.P. and Gireesh, C., "Mutation studies in horsegram (*Macrotyloma uniflorum* (Lam.) Verdc)", 2006, LSS-2006, BARC, Mumbai (MS), India. 88-89.

[25] Sagade, S.V., "Genetic improvement of urdbean (*Vigna mungo* L. Hepper) through mutation breeding", 2008, Ph.D. Thesis, University of Pune, Pune (MS), India.

[26] Shambulingappa, R.G., Viswanatha, K.P. In: Proceedings FAO Library Accession No: 342227 FicheNo: 342209-251.

[27] Sing, V.P., Sing, M. and Lal, J.P., 'Gamma rays and EMS induced genetic variability for quantitative traits in urdbean (*Vigna mungo* L. Hepper)". *Indian J. Genet*., 2000, 60 (1): 89-96.

[28] Singh, R.K. and Raghuvanshi, S.S., 'Pentaphyllus mutant in *Vigna mungo* (Urd)", *Curr. Sci.*, 1985, 54 (24): 1286-1287.

[29] Tambe, A.B., "Induction of genetic variability in Soybean (*Glycine max* (L.) Merrill) for yield contributing traits", 2009, Ph.D. Thesis, University of Pune, Pune (MS), India.

[30] Vandana and Dubey, D.K., "Effect of EMS and DES on germination, growth, fertility and yield of lentil var. K 85 (Macrosperma)", *Lens Newsletter*, 1990, 17 (2): 8-12.

[31] Waghmare, V.N. and Mehra, R.B., "Induced genetic variability for quantitative characters in grasspea (*Lathyrus sativus* L.)", *Indian J. Genet*., 2000, 60 (1): 81-87.

[32] Yaqoob, M. and Abdur, R., "Induced mutations studies in some mungbean (*Vigna radiata* L. Wilczek) cultivars". *J. Biol Sci*., 2001, 1 (9): 805-808.

AUTHORS

First Author – Dr. Bolbhat Sadashiv N., Assistant Professor, Department of Botany, Dada Patil Mahavidyalaya Karjat, Dist-Ahmednagar-414402 (M.S.), India., E-mail bolbhats@gmail.com
Second Author – Dr. Dhumal Kondiram N. Department of Botany, University of Pune, Pune-411007 (M.S.) India.

Table 1: Micromutations in M_2 generation of horsegram cv. Dapoli Kulthi-1.

Treat	Plant height (cm)	Pri. br./ plant	DAS for first flowering	DAS for first pod maturity	No. of pods/ plant	Pod length (cm)	No. of seeds/ pod	1000 seed Wt. (g)	Seed yield/ plant (g)
Control	46.70±2.27	6.30±0.25	53.30±2.13	85.20±3.41	71.20±2.85	6.33±0.25	7.20±0.29	26.80±1.07	14.54±0.58
100Gy	35.40±1.77	6.66±0.33	53.07±2.65	81.70±4.09	67.70±3.39	6.20±0.31	6.66±0.33	28.30±1.42	13.36±0.67
200	39.40±2.76	6.20±0.43	53.70±3.76	78.90±5.52	59.50±4.17	6.10±0.43	6.33±0.44	28.20±1.97	11.22±0.79
300	41.30±1.24	7.66±0.23	54.80±1.64	84.60±2.54	83.80±2.51	6.30±0.19	7.10±0.21	27.50±0.83	16.76±0.50
400	40.10±2.41	6.10±0.37	54.70±3.28	84.40±5.06	71.30±4.28	6.10±0.37	6.33±0.38	26.30±1.58	12.87±0.77
0.2 %EMS	53.60±3.22	6.33±0.38	53.40±3.20	79.40±4.76	93.80±5.63	5.60±0.34	6.33±0.38	26.70±1.60	16.45±0.99
0.3	42.70±1.71	7.33±0.29	53.60±2.14	81.30±3.25	50.40±2.02	5.70±0.23	6.33±0.25	25.70±1.03	9.40±0.38
0.4	38.20±2.67	5.33±0.37	53.20±3.72	85.90±6.01	33.40±2.34	5.64±0.40	6.33±0.44	26.60±1.86	7.42±0.52
0.5	43.20±1.30	6.33±0.19	52.80±1.58	83.60±2.51	75.30±2.26	5.58±0.17	6.20±0.19	27.20±0.82	13.30±0.40
100Gy + 0.2%EMS	28.70±1.44	6.10±0.31	49.40±2.47	79.20±3.96	38.40±1.92	5.75±0.29	6.20±0.31	25.60±1.28	8.83±0.44
100 + 0.3	29.40±0.88	8.40±0.25	47.60±1.43	77.30±2.32	49.70±1.49	5.25±0.16	6.10±0.18	26.50±0.80	7.64±0.23
100 + 0.4	26.50±1.59	5.60±0.34	47.30±2.84	79.70±4.78	37.80±2.27	5.50±0.33	6.30±0.38	26.20±1.57	8.46±0.51
100 + 0.5	31.20±2.18	5.10±0.36	47.50±3.33	78.60±5.50	41.40±2.90	5.75±0.40	6.00±0.42	27.50±1.93	8.29±0.58
200 + 0.2	33.20±1.33	5.90±0.24	49.30±1.97	77.80±3.11	38.70±1.55	5.50±0.22	6.50±0.26	27.60±1.10	8.87±0.35
200 + 0.3	25.70±1.29	6.10±0.31	49.40±2.47	79.30±3.97	41.30±2.07	5.10±0.26	6.20±0.31	26.60±1.33	9.12±0.46
200 + 0.4	27.50±1.93	6.20±0.43	47.60±3.33	79.80±5.59	40.70±2.85	5.50±0.39	6.00±0.42	27.80±1.95	9.76±0.68
200 + 0.5	30.20±0.91	7.10±0.21	49.20±1.48	78.50±2.36	39.80±1.19	5.50±0.17	6.50±0.20	26.30±0.79	8.90±0.27
300 + 0.2	34.30±1.71	6.50±0.33	54.90±2.75	79.40±3.97	54.80±2.74	5.50±0.28	7.10±0.36	26.40±1.32	13.10±0.65
300 + 0.3	31.20±1.87	7.10±0.43	54.40±3.26	79.60±4.78	50.70±3.04	5.25±0.32	7.00±0.42	26.60±1.60	11.53±0.69
300 + 0.4	29.10±1.16	5.20±0.21	54.30±2.17	78.70±3.15	33.50±1.34	5.50±0.22	7.10±0.28	30.50±1.22	9.98±0.40
300 + 0.5	35.30±1.06	9.10±0.27	50.80±1.52	80.60±2.42	71.70±2.15	5.30±0.16	7.10±0.21	29.80±0.89	16.01±0.48
400 + 0.2	42.50±2.98	7.80±0.55	50.40±3.53	76.80±5.38	71.40±5.00	5.50±0.39	6.50±0.46	28.70±2.01	14.44±1.01
400 + 0.3	33.20±1.99	6.60±0.40	56.30±3.38	77.60±4.66	70.40±4.22	5.50±0.33	7.10±0.43	25.80±1.55	12.69±0.76
400 + 0.4	40.90±2.05	6.70±0.34	33.80±2.04	57.70±3.39	52.80±2.64	5.10±0.26	6.20±0.31	27.70±1.39	10.38±0.52
400 + 0.5	47.50±1.90	8.30±0.33	40.60±1.62	66.80±2.67	74.40±2.98	5.10±0.20	6.20±0.25	27.70±1.11	14.10±0.56
SEM±	1.83	0.27	2.17	3.37	2.45	0.24	0.27	1.15	0.49
F-value	36.45	27.27	7.14	3.45	99.91	4.54	4.27	2.21	68.91
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
$LSD_{0.05}$	3.58	0.39	2.08	6.61	4.80	0.47	0.53	2.25	0.96

Data are means of three replicates ± standard deviation. Significant difference due to treatments was assessed by Fisher's LSD as post-hoc test.

Table 2: Micromutations in M_3 generation of horsegram cv. Dapoli Kulthi-1.

Treat	Plant height (cm)	Pri. br./ plant	DAS for first flowering	DAS for 1st pod maturity	No. of pods/ plant	Pod length (cm)	No. of seeds/ pod	1000 seed Wt. (g)	Seed yield/ plant (g)
Control	50.99±4.89	10.99±0.88	54.00±1.00	83.00±1.00	100.55±7.56	6.65±0.25	6.84±0.50	25.07±0.81	16.58±2.94
100Gy	49.73±2.00	12.58±0.96	53.67±3.54	82.44±4.11	106.18±8.90	6.44±0.51	6.83±0.51	25.31±1.60	18.62±2.34
200	44.57±4.56	11.49±2.44	54.72±1.60	84.45±2.52	110.04±2.33	6.40±0.35	6.84±0.17	26.05±0.58	19.14±1.37
300	49.85±1.74	11.98±2.37	50.98±1.10	79.17±0.55	110.32±18.11	6.52±0.33	6.85±0.32	25.93±0.50	19.60±.25
400	48.75±1.06	10.03±3.26	54.77±1.53	85.78±3.32	109.62±24.38	6.51±0.24	6.88±0.21	26.70±2.01	18.90±.54
0.2 %EMS	47.39±1.38	10.73±3.34	51.73±1.69	80.53±3.46	107.82±22.08	6.25±0.10	6.46±0.13	24.56±1.71	16.34±3.94
0.3	49.32±4.45	9.32±3.25	56.17±0.55	87.07±1.67	96.04±40.93	6.62±0.56	7.02±0.35	26.36±0.82	16.13±7.24
0.4	48.46±6.44	8.26±3.87	53.59±0.52	82.21±1.36	69.23±21.92	6.04±0.39	6.36±0.30	24.76±1.02	11.26±3.93
0.5	46.82±9.95	6.51±0.81	54.57±4.69	84.53±6.41	66.82±18.57	6.36±1.02	6.63±0.77	25.08±1.18	10.93±3.42
100Gy + 0.2%EMS	45.10±4.55	6.78±1.02	54.00±1.73	83.67±0.58	86.88±25.68	6.38±0.45	6.55±0.39	24.80±0.48	14.12±4.18
100 + 0.3	48.50±4.18	6.39±1.16	52.63±3.57	81.31±2.84	100.11±21.59	6.36±0.50	6.53±0.37	24.14±1.00	16.35±3.01
100 + 0.4	49.27±3.72	7.30±2.07	54.86±0.24	84.16±1.89	90.25±14.74	6.40±0.21	6.62±0.09	24.56±1.38	14.95±2.57
100 + 0.5	46.11±3.89	8.48±3.69	51.44±1.78	79.18±0.31	93.33±11.95	6.06±0.31	6.42±0.19	22.84±0.87	15.27±2.04
200 + 0.2	50.61±2.43	11.25±2.22	57.34±1.37	88.66±2.50	85.22±5.02	6.58±0.28	7.08±0.38	25.53±0.64	13.83±1.53
200 + 0.3	45.81±4.97	11.06±1.75	52.94±0.12	81.86±2.02	93.42±6.60	6.05±0.15	6.54±0.41	23.85±0.80	15.71±1.51
200 + 0.4	50.42±5.85	10.44±1.41	58.12±2.53	89.82±1.93	97.28±14.90	6.63±0.14	7.16±0.24	27.31±2.22	16.96±2.03
200 + 0.5	47.07±4.45	9.68±1.34	53.23±1.66	82.65±3.24	86.53±5.66	6.10±0.29	6.54±0.54	25.09±2.61	14.71±0.90
300 + 0.2	50.94±3.93	9.64±1.62	55.64±5.05	85.75±5.88	83.49±15.54	6.20±0.40	6.52±0.50	25.81±0.55	13.68±2.67
300 + 0.3	50.78±2.41	9.11±1.58	54.67±1.53	84.00±1.00	87.33±14.73	6.11±0.10	6.18±0.32	24.28±0.23	13.52±2.96
300 + 0.4	47.00±2.82	8.67±1.45	45.19±11.92	76.23±6.93	87.18±18.38	6.03±0.40	6.84±0.31	24.27±2.00	13.40±3.28
300 + 0.5	46.03±7.36	9.87±2.57	46.71±14.47	78.44±11.7	92.39±11.07	6.25±0.14	6.42±0.48	24.57±1.33	14.23±2.38
400 + 0.2	44.10±8.39	9.67±1.84	43.29±12.82	72.35±9.19	102.18±9.82	5.93±0.24	5.82±0.11	23.45±1.81	13.30±2.21
400 + 0.3	41.84±9.19	10.51±2.72	49.88±14.63	76.90±21.6	98.42±11.79	6.64±0.48	6.74±0.06	25.65±2.65	15.59±2.73
400 + 0.4	49.12±8.17	9.22±1.35	42.34±12.70	71.14±18.4	96.08±7.25	6.14±0.46	6.18±0.32	24.40±2.12	15.20±1.83
400 + 0.5	48.91±4.39	11.01±2.21	48.52±12.34	74.68±17.84	85.53±9.43	6.43±0.26	6.78±0.53	25.52±1.12	15.18±3.05
SEM±	2.06	0.41	2.23	3.47	4.04	0.27	0.28	1.06	0.67
F-value	2.13	30.82	5.79	3.71	15.86	1.38	2.39	1.85	22.75
P-value	1.24	3.28	8.76	4.57	6.81	1.69	4.77	3.40	2.95
$LSD_{0.05}$	-	-	-	-	-	-	-	-	-

Data are means of three replicates ± standard deviation. Significant difference due to treatments was assessed by Fisher's LSD as a post-hoc test.