“INDUCED MUTATION IN GREENGRAM
[Vigna radiata (L.) Wilczek ] THROUGH GAMMA RAY IRRADIATION ”

A

Thesis submitted to the

Bidhan Chandra Krishi Viswavidyalaya

in partial fulfilment of the requirements for the Award of the Degree of

Doctor of Philosophy (Agriculture)

in

Genetics

By

Srijib Panda

Bidhan Chandra Krishi Viswavidyalaya

DEPARTMENT OF GENETICS

FACULTY OF AGRICULTURE

MOHANPUR, NADIA, WEST BENGAL, INDIA

2007
Dedicated to...

Baba O Maa
APPROVAL OF EXAMINERS FOR THE AWARD OF
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN GENETICS

We, the undersigned having been satisfied with the performance of Sri Srijib Panda
in the viva-voce examination, conducted today, ....................... 2007, recommended
that the thesis be accepted for the award of the degree.

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dr. G. Sarkar</td>
<td>Chairman (Advisory Committee)</td>
<td></td>
</tr>
<tr>
<td>2. Dr. N. D. Majumder</td>
<td>External Examiner</td>
<td></td>
</tr>
<tr>
<td>3. Prof. S. K. Ghose</td>
<td>Member (Advisory Committee)</td>
<td></td>
</tr>
<tr>
<td>4. Prof. S. K. Bandyopadhyay</td>
<td>Member (Advisory Committee)</td>
<td></td>
</tr>
<tr>
<td>5. Dr. B. K. Senapati</td>
<td>Member (Advisory Committee)</td>
<td></td>
</tr>
<tr>
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<td>Head (Dept. of Genetics)</td>
<td></td>
</tr>
</tbody>
</table>
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At the nib but not the neap tide I solicit the benediction of Almighty God for the progress and prosperity of my life.

Needless to say, errors and omission are mine.

Place: ....Mahan Puri
Dated: ....-0-0-7

(Srijib Panda)
CERTIFICATE

This is to certify that the work recorded in the thesis, entitled "INDUCED MUTATION IN GREENGRAM [Vigna radiata (L.) Wilczek] THROUGH GAMMA RAY IRRADIATION", submitted by Sri Srijib Panda in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Agriculture) in Genetics of the Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal is the record of faithful and bonafide research work carried out by Sri Panda under my direct supervision and guidance. The results of the investigation reported in this thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of the investigation have been duly acknowledged.

( G. SARKAR )
Chairman, Advisory Committee
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>CONTENT</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>INTRODUCTION</td>
<td>1 - 5</td>
</tr>
<tr>
<td>2.</td>
<td>REVIEW OF LITERATURE</td>
<td>6 - 23</td>
</tr>
<tr>
<td>2.1</td>
<td>Radio sensitivity studies</td>
<td>6 - 9</td>
</tr>
<tr>
<td>2.2</td>
<td>Chlorophyll mutation</td>
<td>9 - 11</td>
</tr>
<tr>
<td>2.3</td>
<td>Morphological mutation</td>
<td>11 - 12</td>
</tr>
<tr>
<td>2.4</td>
<td>Induced variability for yield attributes</td>
<td>13 - 23</td>
</tr>
<tr>
<td>3.</td>
<td>MATERIALS AND METHODS</td>
<td>24 - 34</td>
</tr>
<tr>
<td>3.1</td>
<td>Materials</td>
<td>24</td>
</tr>
<tr>
<td>3.2</td>
<td>Location of experiments</td>
<td>25</td>
</tr>
<tr>
<td>3.3</td>
<td>Soil type of the experimental field</td>
<td>25</td>
</tr>
<tr>
<td>3.4</td>
<td>Climate</td>
<td>25 - 27</td>
</tr>
<tr>
<td>3.5</td>
<td>Mutagen and methods of treatment</td>
<td>28</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Mutagen</td>
<td>28</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Methods</td>
<td>28</td>
</tr>
<tr>
<td>3.6</td>
<td>M&lt;sub&gt;1&lt;/sub&gt; generation</td>
<td>29</td>
</tr>
<tr>
<td>3.7</td>
<td>M&lt;sub&gt;2&lt;/sub&gt; generation</td>
<td>29</td>
</tr>
<tr>
<td>3.8</td>
<td>M&lt;sub&gt;3&lt;/sub&gt; generation</td>
<td>30</td>
</tr>
<tr>
<td>3.9</td>
<td>Biometrical parameters</td>
<td>30</td>
</tr>
<tr>
<td>3.9.1</td>
<td>Biological yield (g)</td>
<td>30</td>
</tr>
<tr>
<td>3.9.2</td>
<td>Plant height (cm)</td>
<td>30</td>
</tr>
<tr>
<td>3.9.3</td>
<td>Number of branches per plant</td>
<td>30</td>
</tr>
<tr>
<td>3.9.4</td>
<td>Number of pods per plant</td>
<td>30</td>
</tr>
<tr>
<td>3.9.5</td>
<td>Number of cluster per plant</td>
<td>30</td>
</tr>
<tr>
<td>3.9.6</td>
<td>Pod length</td>
<td>31</td>
</tr>
<tr>
<td>3.9.7</td>
<td>Number of seeds per pod</td>
<td>31</td>
</tr>
<tr>
<td>3.9.8</td>
<td>100 seed weight</td>
<td>31</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>CONTENT</td>
<td>PAGE NO.</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>3.9.9</td>
<td>Seed yield per plant (g)</td>
<td>31</td>
</tr>
<tr>
<td>3.9.10</td>
<td>Harvest index</td>
<td>31</td>
</tr>
<tr>
<td>3.9.11</td>
<td>Statistical analysis</td>
<td>31 - 34</td>
</tr>
<tr>
<td>4.</td>
<td>RESULT AND DISCUSSION</td>
<td>35 - 58</td>
</tr>
<tr>
<td>4.1</td>
<td>M$_1$ generation</td>
<td>35</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Germination and survival of two varieties in mungbean</td>
<td>35</td>
</tr>
<tr>
<td>4.2</td>
<td>Induced variability for polygenic traits in M$_1$ generation</td>
<td>36</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Biological yield (g)</td>
<td>36</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Plant height (cm)</td>
<td>36</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Branch number per plant</td>
<td>37</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Number of pods per plant</td>
<td>38</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Pod length (cm)</td>
<td>38 - 39</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Number of seeds per pod</td>
<td>39</td>
</tr>
<tr>
<td>4.2.7</td>
<td>100 seed weight (g)</td>
<td>39</td>
</tr>
<tr>
<td>4.2.8</td>
<td>Seed yield per plant (g)</td>
<td>39 - 40</td>
</tr>
<tr>
<td>4.2.9</td>
<td>Harvest index</td>
<td>40</td>
</tr>
<tr>
<td>4.3</td>
<td>M$_2$ generation</td>
<td>41</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Chlorophyll mutations in mungbean</td>
<td>41 - 42</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Macro mutation in mungbean</td>
<td>42</td>
</tr>
<tr>
<td>4.4</td>
<td>Induced variability for polygenic traits in M$_2$ generation</td>
<td>42</td>
</tr>
<tr>
<td>4.4.1</td>
<td>Biological yield (g)</td>
<td>43</td>
</tr>
<tr>
<td>4.4.2</td>
<td>Plant height (cm)</td>
<td>43 - 44</td>
</tr>
<tr>
<td>4.4.3</td>
<td>Branch number per plant</td>
<td>44 - 45</td>
</tr>
<tr>
<td>4.4.4</td>
<td>Number of pods per plant</td>
<td>45</td>
</tr>
<tr>
<td>4.4.5</td>
<td>Pod length (cm)</td>
<td>45 - 46</td>
</tr>
<tr>
<td>4.4.6</td>
<td>Number of seeds per pod</td>
<td>46</td>
</tr>
<tr>
<td>4.4.7</td>
<td>100 seed weight (g)</td>
<td>47</td>
</tr>
<tr>
<td>4.4.8</td>
<td>Seed yield per plant (g)</td>
<td>47 - 48</td>
</tr>
<tr>
<td>4.4.9</td>
<td>Harvest index</td>
<td>48</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>CONTENT</td>
<td>PAGE NO.</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>4.5</td>
<td>M₃ generation</td>
<td>49</td>
</tr>
<tr>
<td>4.6</td>
<td>Induced variability for polygenic traits in M₃ generation</td>
<td>50</td>
</tr>
<tr>
<td>4.6.1</td>
<td>Biological yield (g)</td>
<td>51</td>
</tr>
<tr>
<td>4.6.2</td>
<td>Plant height (cm)</td>
<td>51</td>
</tr>
<tr>
<td>4.6.3</td>
<td>Branch number per plant</td>
<td>52</td>
</tr>
<tr>
<td>4.6.4</td>
<td>Number of pods per plant</td>
<td>52</td>
</tr>
<tr>
<td>4.6.5</td>
<td>Number of clusters per plant</td>
<td>53</td>
</tr>
<tr>
<td>4.6.6</td>
<td>Pod length (cm)</td>
<td>53-54</td>
</tr>
<tr>
<td>4.6.7</td>
<td>Number of seeds per pod</td>
<td>54</td>
</tr>
<tr>
<td>4.6.8</td>
<td>100 seed weight (g)</td>
<td>54-55</td>
</tr>
<tr>
<td>4.6.9</td>
<td>Seed yield per plant (g)</td>
<td>55</td>
</tr>
<tr>
<td>4.6.10</td>
<td>Harvest index</td>
<td>55-56</td>
</tr>
<tr>
<td>4.7</td>
<td>Selection gain</td>
<td>56-57</td>
</tr>
<tr>
<td>4.8</td>
<td>Comparison of means of different characters at M₃ generation</td>
<td>57-58</td>
</tr>
<tr>
<td>5.</td>
<td>SUMMARY AND CONCLUSION</td>
<td>59-61</td>
</tr>
<tr>
<td>6.</td>
<td>FUTURE SCOPE OF RESEARCH</td>
<td>62-63</td>
</tr>
<tr>
<td></td>
<td>BIBLIOGRAPHY</td>
<td>i - xi</td>
</tr>
</tbody>
</table>
### LIST OF TABLE

<table>
<thead>
<tr>
<th>TABLE NO.</th>
<th>TITLE</th>
<th>PAGE IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physico-chemical properties of the soil</td>
<td>25</td>
</tr>
<tr>
<td>2.</td>
<td>Meteorological data during the crop growth period (Oct' 2002 to June' 2005)</td>
<td>27</td>
</tr>
<tr>
<td>3.</td>
<td>Germination and survival of dry seeds of two mungbean cultivars at different doses of gamma irradiation</td>
<td>35</td>
</tr>
<tr>
<td>4.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for biological yield (g) in $M_1$</td>
<td>36 - 37</td>
</tr>
<tr>
<td>5.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for plant height (cm) in $M_1$</td>
<td>36 - 37</td>
</tr>
<tr>
<td>6.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for branch number per plant in $M_1$</td>
<td>38 - 39</td>
</tr>
<tr>
<td>7.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of pods per plant in $M_1$</td>
<td>38 - 39</td>
</tr>
<tr>
<td>8.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for pod length (cm) in $M_1$</td>
<td>38 - 39</td>
</tr>
<tr>
<td>9.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of seeds per pod in $M_1$</td>
<td>39 - 40</td>
</tr>
<tr>
<td>10.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for 100 seed weight (g) in $M_1$</td>
<td>39 - 40</td>
</tr>
<tr>
<td>11.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for seed yield per plant (g) in $M_1$</td>
<td>39 - 40</td>
</tr>
<tr>
<td>12.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for harvest index in $M_1$</td>
<td>39 - 40</td>
</tr>
<tr>
<td>TABLE NO.</td>
<td>TITLE</td>
<td>PAGE NO.</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>13.</td>
<td>Frequency and spectrum of chlorophyll mutations in M₂ generation of PDM-84-139 and B-1</td>
<td>41</td>
</tr>
<tr>
<td>14.</td>
<td>Spectrum and frequency of macro mutations in B-1 and PDM-84-139 in M₂ generation</td>
<td>41 - 42</td>
</tr>
<tr>
<td>15.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for biological yield (g) in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>16.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for plant height (cm) in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>17.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for branch number per plant in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>18.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of pods per plant in M₂</td>
<td>45 - 46</td>
</tr>
<tr>
<td>19.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for pod length (cm) in M₂</td>
<td>45 - 46</td>
</tr>
<tr>
<td>20.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of seeds per pod in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>21.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for 100 seed weight (g) in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>22.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for seed yield per plant (g) in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>23.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for harvest index in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>24.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for biological yield (g) in M₃</td>
<td>52 - 53</td>
</tr>
<tr>
<td>25.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for plant height (cm) in M₃</td>
<td>52 - 53</td>
</tr>
<tr>
<td>TABLE NO.</td>
<td>TITLE</td>
<td>PAGE IN BETWEEN</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>13.</td>
<td>Frequency and spectrum of chlorophyll mutations in M₂ generation of PDM-84-139 and B-1</td>
<td>41</td>
</tr>
<tr>
<td>14.</td>
<td>Spectrum and frequency of macro mutations in B-1 and PDM-84-139 in M₂ generation</td>
<td>41 - 42</td>
</tr>
<tr>
<td>15.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for biological yield (g) in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>16.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for plant height (cm) in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>17.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for branch number per plant in M₂</td>
<td>44 - 45</td>
</tr>
<tr>
<td>18.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of pods per plant in M₂</td>
<td>45 - 46</td>
</tr>
<tr>
<td>19.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for pod length (cm) in M₂</td>
<td>45 - 46</td>
</tr>
<tr>
<td>20.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of seeds per pod in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>21.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for 100 seed weight (g) in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>22.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for seed yield per plant (g) in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>23.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for harvest index in M₂</td>
<td>47 - 48</td>
</tr>
<tr>
<td>24.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for biological yield (g) in M₃</td>
<td>52 - 53</td>
</tr>
<tr>
<td>TABLE NO.</td>
<td>TITLE</td>
<td>PAGE IN BETWEEN</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>25.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for plant height (cm) in $M_3$</td>
<td>52 - 53</td>
</tr>
<tr>
<td>26.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for branch number per plant in $M_3$</td>
<td>52 - 53</td>
</tr>
<tr>
<td>27.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of pods per plant in $M_3$</td>
<td>52 - 53</td>
</tr>
<tr>
<td>28.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of clusters per plant in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>29.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for pod length (cm) in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>30.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for number of seeds per pod in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>31.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for 100 seed weight (g) in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>32.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for seed yield per plant (g) in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>33.</td>
<td>Mean, range, variance, GCV, PCV, $h^2$ and Genetic Advance as percentage of mean for harvest index in $M_3$</td>
<td>55 - 56</td>
</tr>
<tr>
<td>34.</td>
<td>Selection response for biological yield, plant height, branch number per plant total number of pods and cluster number per plant in $M_3$ generation</td>
<td>56 - 57</td>
</tr>
<tr>
<td>35.</td>
<td>Means of different characters under study at $M_3$ generation along with parental generation and Duncan's test results</td>
<td>56 - 57</td>
</tr>
</tbody>
</table>
# LIST OF PLATES

<table>
<thead>
<tr>
<th>PLATE NO.</th>
<th>TITLE</th>
<th>PAGE IN BETWEEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Normal plant of variety PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>2.</td>
<td>Dwarf mutant plant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>3.</td>
<td>Bushy mutant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>4.</td>
<td>Synchronous maturing mutant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>5.</td>
<td>Tall mutant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>6.</td>
<td>Top bearing mutant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>7.</td>
<td>Early maturing mutant in PDM-84-139</td>
<td>49 - 50</td>
</tr>
<tr>
<td>8.</td>
<td>Normal plant of variety B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>9.</td>
<td>Erect plant mutant in B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>10.</td>
<td>Synchronous maturing mutant in B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>11.</td>
<td>Higher pod bearing mutant in B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>12.</td>
<td>Bushy mutant in B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>13.</td>
<td>Tall and late maturing mutant in B-1</td>
<td>50 - 51</td>
</tr>
<tr>
<td>14.</td>
<td>Sterile mutant in B-1</td>
<td>50 - 51</td>
</tr>
</tbody>
</table>
Chapter – 1

INTRODUCTION
INTRODUCTION

Greengram also called as mungbean \([Vigna radiata\) (L.) Wilczek\] \(2n = 2x = 22\) is an important grain legume which is extensively grown in India and South Asian Countries on all types of soil and varying climatic conditions. Being a leguminous crop, it occupying an important position in Indian agriculture and its position is third after chick pea and pigeon pea. In India, greengram is mainly cultivated in Rajasthan, Maharashtra, Andhra Pradesh, Orissa, Karnataka, Bihar, UP and West Bengal in two season i.e kharif and summer. During the last few years the area of greengram has reduced. Production has also decreased but the productivity fluctuates and has increased marginally. On the other hand, the demand of pulses as a whole has increased. During 1990-91 the area, production and productivity were 3.36 million ha, 1.38 million tonnes and 413 Kg/ha respectively. But during the year 2000-01, the corresponding figures were 3.08 million ha, 1.05 million tonnes and 342 Kg/ha. In West Bengal, during 1980-85, the area, production and productivity of greengram were 3 million ha, 0.17 million tonnes and 583 kg/ha respectively. During 1995-2000 the area, production and productivity were 0.15 million ha, 0.06 million tonnes and 411 kg/ha respectively.

After green revolution in India, the area, production and productivity of cereals have increased many times. The production of rice and wheat have increased 4 and 10 times respectively. But the overall scenario of pulses production is very gloomy, it has not even been doubled. The poor yield performance of most of the pulses including greengram are many like excessive indeterminate vegetative growth habit, low harvest index, defective plant type, non-synchronous maturity, pod shattering, non availability of good quality seeds of improved variety or HYV, susceptibility to various biotic (pests and diseases e.g. pod borer, thrips, bruchids, YMV, powdery mildew etc.) and abiotic stresses (drought, flood, low or high temperature etc.) and overall restricted cultivation in the marginal lands under resource poor conditions without any proper crop management.

Greengram is a short duration (60 – 70 days) crop and an excellent source of protein (20 - 26 %), 3.3 % fat, 5.9 % fibre, 51.2% carbohydrate, 3 – 4 % minerals and 0.3 % vitamins with high digestibility. Greengram seeds are highly nutritious and are eaten
Introduction

whole or split (dál), boiled or germinated. Greengram is rich in different amino acids required for repairs of cells and maintenance of body such as cystin (55 mg), isolucine (264 mg), lucine (484 mg), lysine (43 mg), methionine (75 mg), phenylalanine (378 mg), threonine (205 mg), tryptophan (68 mg), tyrosine (187 mg) and valine (324 mg) expressed in milligrams per gram of nitrogen (Haytowitz and Mathew, 1986). Minerals like Ca, Fe, Mg, P, K, Na, Zn, Cu, Mn and vitamins such as ascorbic acid, thiamin, riboflavin, niacin and vitamin A are also present in greengram seed. Greengram seeds contain less amount of trypsin inhibitors than any other legumes and it is removed remarkably by moist heat treatment. Poly phenols (3.7 milligram) are recognized as anti physiological substance. They are heat stable and are known to decrease the protein and carbohydrate digestibility and availability of vitamins. But the poly phenols are present in higher concentration in seed coat than cotyledon. Therefore, dehulling substantially reduce the phenolic composition. Greengram is considered to have least majority of poly phenols because the presence of stachyose and verbascose, the sugars of oligosaccharide family is very low and they removed during germination and cooking. Thus by considering the chemical composition and various uses, greengram emerged as an important pulse crop. In addition to these, being a leguminous crop evergreen has the capacity of fixing atmospheric nitrogen (40-50 kg/ha) in the soil and augment soil health with the help of *Rhizobium* sp. present in the root nodule.

Greengram is originated in Indo-Burma region of South East Asia. Vavilov identified Central Asiatic Centre, which include North West India, Afganistan and adjoining Soviet Republics, as primary center of origin of green gram. Greengram has been cultivated in India since very early times and carbonized grains of this crop are found in Chalcolithic site, Navdatoli - Maheshwari in MP in 1660 – 1440 BC. (Vishnu Mettre, 1974). Presence of wild progenitor of *Vigna radiata* var Sublobata also indicates India and Indo-Burma region as Centre of Origin of this pulse crop.

Improvement of cultivated plants largely depends on the extent of genetic variability available within the species of a crop. Greengram being an important pulse crop and self-pollinated in nature, poses limited variability. Induced mutagenesis now been accepted as a useful tool to create genetic variability in a short period of time and
Introduction

now can be used to generate useful variations in quantitatively inherited traits when appropriate selection is applied for improvement (Brock, 1970; Kaul and Kumar, 1983).

Crop improvement programme through induced mutations were initiated about seven decades ago, immediately after the discovery of mutagenic actions of X-ray on fruit fly (Drosophila melanogaster) by Müller in 1927, and in maize, barley and wheat by Stadler in 1928 and 1930. These two discoveries resulted almost immediately in the practical recovery of some economically useful mutants in wheat (Delaunay, 1931 and Sapehin, 1930, 1936). Significant contributions in understanding basic and applied nature of mutation phenomenon, cereal and legume crops were made in Sweden (Gustafsson et al., 1967) and Germany (Gaul et al., 1969; Gottschalk and Wolfe, 1983).

Induction of mutation in recent years has gained much attention due to the rapid and increasing availability of atomic energy. It offers the best possible approach towards improvement of a crop in a shortest possible time. Extensive works on mutation breeding have demonstrated that many agronomic characters of a crop plant may be improved further through the proper application of the induced mutagenesis followed by appropriate selection. It is now well established that mutagens not only increase the initial variability in a crop plant but also provide greater scopes to select genotypes with improved desirable characters (Swaminathan, 1965; Thakre et al. 1980a; Gupta et al. 1982; Nigam et al. 1990; Sumabai and Nayar, 1995). The radiation technique and its methods of application have been changed. The effect of chronic irradiation of different stages of growing plants have thoroughly been studied by a number of workers (Conger and Giles, 1950; Cummings et al. 1955; Powell and Burton, 1965; Conger et al. 1973).

The possibility of using gamma rays as a physical agent for creating hereditary changes in desirable characters of crop plants has been reported by earlier workers. Consequently the high yielding varieties of gram (CM-72, NIFA 88), cotton and other crops have been developed through gamma rays which act as an effective alternate method of conventional breeding approaches. Gamma irradiation as a mutagen can induce useful as well as harmful mutations in plants. It is thus essential to predict the most useful dose of gamma rays for improvement of specific traits of crop plants. Several attempts have been made in this regard to evolve the desirable plants by using physical
and chemical mutagens or the combinations of both and some positive results have already been achieved.

Over 2252 mutant varieties of crop plant including cereals, oilseeds, pulses, vegetables, fruits, fibers and ornamentals have been developed by the end of 20th century. More than 60% of these mutant varieties were developed and released after 1985. while, 1585 varieties were released as direct mutants, the rest were released through cross breeding with mutants. Most of the mutant varieties (around 89%) have been developed using physical mutagens (X rays, gamma rays, Thermal and Fast neutrons), with gamma rays alone accounting for the development of 60% of the mutant varieties (Kharkwal, Pandey and Pawar, 2004).

Greengram or mungbean ([*Vigna radiata* (L.) Wilczek] is one of the important pulses grown in India either as a kharif or summer crop on varying types of soil and climatic conditions. Yield is unstable both over location and seasons due to susceptibility of the cultivars to environmental stresses (drought or flood), diseases like Mungbean Yellow Mosaic Viruses (MYMV).

In this background, development of mungbean varieties with higher yield potential, greater yield stability and increased production efficiency and synchronous maturity are the foremost task of the present and future genetic enhancement research programme. Various steps are to be taken to achieve the goal, the major ones being interrogation of useful genes from the related wild species, development of ideal plant type with optimum harvest index, exploitation of hybrid vigour through CMS based hybrids, incorporation of multiple and broad based resistance against major diseases. Unlike other crops, the genetic base in pulses including greengram is very narrow. Wider genetic variability is prerequisite for any crop for further improvement. Therefore, in pulses mutagenesis has been an excellent tool for creating genetic variability number of oligogenes. Because of narrow genetic variability in cultivated greengram, technique like embryo rescue and creation of genetic variability through mutation breeding will be very much useful in future research programme for the improvement of this important pulse crop.
Introduction

A wide range of characters which have been improved through mutation breeding include plant architecture, yield, flowering and maturity duration, quality and tolerance to biotic and abiotic stresses. Since pre-independence era to till date a number of improved greengram varieties have been developed following either hybridization or mutation breeding programme by the breeders and recommended for cultivation in different States of India. No doubt some progress has been made. But to be competitive with other crops improvement of greengram in respect of yield, early and synchronous maturity determinate growth habit as well as tolerance to biotic and abiotic stresses are yet to be made. Keeping these objectives in view the present gamma ray induced mutation breeding programme has been undertaken and an attempt has been made to assess the level and magnitude of variability for characters like biological yield (g), plant height (cm), branch number per plant, number of pods per plant, number of clusters per plant, pod length (cm), number of seeds per pod, 100 seed weight (g), seed yield per plant (g), harvest index etc. in M₁, M₂ and M₃ generations of greengram [Vigna radiata (L) Wilczek] cv. B-1 & PDM-84-139 by treating dry seeds with different doses (30, 50 and 70 KR) of gamma rays as mutagen.
Chapter – 2

REVIEW OF LITERATURE
2.1 Radio sensitivity studies in greengram:

Radiosensitivity of different genotypes in a crop is estimated in terms of the damage done by treatment with radiations. Different parameters have been used on different crops to measure this damage by several workers for instance; Dahiya (1973, 1978) studied radiosensitivity of two mungbean genotypes on the basis of germination and found a dose of 70 KR gamma rays to be appropriate for Pusa Baisakhi and Hybrid – 45, the latter being more tolerant to radiation treatment.

Singh and Pandya (1977) studied the radiosensitivity in mungbean. The dose levels 40 and 50 KR were found to be critical for varieties such as T 44 and ML 26.

In another study, in greengram varieties like T 44 and ML 26, 40-50 KR doses were found to be critical (Singh et al. 1979).

Subramanian (1980) later examined the radiosensitivity of three Vigna species (Vigna radiata, Vigna aconitifolia and Vigna trilobita), using parameters like germination, survival, growth rate etc. According to him LD 50 was 20 KR and lethal dose was 50 KR.

Krishnaswami and Rathinam (1980) took 10 different cultivars of mungbean (S-8, Selection 122, Pusa Baisakhi, NP-36, L 24/2, ML-5, Jawahar 45, Kopergaon, PS-10 and Niagara Selection) for radiation treatments ranging from 20-60 KRad. Pusa Baisakhi was found to be most sensitive, as shown by reduction in survival and hypocotyl length after 20 KRad treatment. However, surprisingly even 60KR dose did not reach the level of LD 50 in this experiment. The higher sensitivity of Pusa Baisakhi was attributed to large seed size, its fast initial growth rate and high productivity and simultaneously in the same way the variety L 24/2 exhibited small seeds with low productivity and a low level of radiosensitivity.
Yadav and Singh (1986) subjected dry seeds (8% moisture) of cultivar T 44 to gamma rays (5-40 KR), ethyl methanesulfonate (EMS) (0.01 – 0.05 M) and combined treatments (40-50 KR followed by 0.02 M EMS). They examined the effect of these treatments on germination, survival, seedling height, plant height, pollen fertility and ovule fertility. High sensitivity of germination followed by survival was observed to these mutagenic treatments. More damage caused by EMS than by gamma rays.

Vanitvatanalumlog et al. (1986) reported the survival of seedlings of gamma-irradiated Uthong 1 at 28 days after germination and the LD50 was 70 KR for the same.

Seeds of Vigna radiata (PS16), Vigna mungo (T9) and Vigna sublobata (a wild relative) were treated with EMS and gamma rays. Doses of 0.1, 0.2, 0.3 and 0.4% EMS, 10, 20, 30 and 40 KR gamma radiation and combined treatments (0.1% + 10 KR, 0.2% + 20 KR, 0.3% + 30 KR and 0.4% + 40 KR) were employed. Mutagenesis lowered dehydrogenase activity in the M1 and M2 of all β species. Dose-dependent decreases were noted in seedling emergence and height, survival and pollen fertility. The spectrum and frequency of chlorophyll mutations increased with dosage. Vigna sublobata was more resistant than the other 2 species while Vigna radiata was the most sensitive. Vigna sublobata is thought to be more closely related to Vigna mungo than to Vigna radiata. (Ignacimuthu and Babu, 1988).

Data were tabulated on germination, survival and 5 morphological traits for plants grown from seeds of varieties J781 and S8 treated with 10-50 KR gamma rays. The greatest variability was induced at 40 and 50 KR. (Mehetre et al. 1990).

Percentage of germination and seedling survival were measured in mungbean cv. T-44 and ML-131 treated with 10-70 KR doses of gamma rays. Seed germination decreased from 94.7% with 10 KR to 22.0% with 70 KR in T-44 and from 88.7% to 4.0% in ML-131, compared with 95.3 and 96.7% in the untreated controls. Seedling survival at 30 days was 100% with up to 20 KR but it decreased to 54.0-54.5% with 70 KR. By maturity 60-70 KR proved lethal for both cultivars (Borah, 1991).
Seeds of *Vigna radiata* variety PS16 were treated with 0.02, 0.04 and 0.06% diethyl sulfate (DES). Data were recorded on seed germination, survival and pollen fertility in the M₁ generation, and on four quantitative traits in M₂ plants. A reduction in seed germination and pollen fertility was noted in the M₁ compared to the control. In the M₂ generation, compared with the untreated control, 0.02 and 0.04% DES treatments increased the mean values of days to flowering, plant height, fertile branches per plant and pods per plant, while 0.06% DES had a negative effect on these characteristics (Khan *et al.* 1994).

Dry seeds (10% moisture content) of Pusa Baisakhi, a standard variety of mungbean were treated with 10, 20, 30 and 40 KR gamma rays. Percentage germination, pollen fertility and plant height showed a linear reduction with increasing gamma ray doses (Sarkar *et al.* 1996).

Dry seeds of *Vigna radiata* cv. B1, LM-23, B-105 and K-851 were exposed to 10, 15 or 20 KR gamma radiation. Seed germination decreased in all cultivars with increase in radiation dose. cv. K-851 was most affected with an LD₅₀ value between 15 and 20 KR. (Mallick *et al.* 1997).

Dry seeds of mungbean cv. PS16 were treated with various doses of gamma rays (20, 30 and 40 KR), EMS (0.05-0.3%) and epichlorohydrin (ECH, 0.4%), and data on seed germination, seedling survival, pollen fertility, mitotic index and seedling vigour were recorded in the F₁ generation. There was a linear relationship between doses of these mutagens and decrease in all these parameters. The mutagenic effectiveness increased with an increase in dose of the mutagens used. Among the three mutagens tested, EMS was the most effective and gamma rays the least effective (Singh *et al.* 1997).

The effect of methyl methane sulphonate (MMS), applied to seeds at concentrations of 0.01, 0.02, 0.03, and 0.04%, on seed germination and pollen fertility was studied by Samiullah *et al.* (2003) on M₁ and M₂ generations of greengram cv. Pusa
Baisakhi. The induced biological damage in terms of seed germination and pollen fertility was found to be dose dependent. Inhibition of seed germination increased with increasing MMS concentration; the highest percentage inhibition was observed at 0.04% MMS (28.55 and 26.43% in the M₁ and M₂, respectively). Reduction in pollen fertility also increased with increasing MMS concentration; the highest percentage reduction was observed at 0.04% (29.72 and 7.94% in the M₁ and M₂, respectively).

The effect of EMS on the seed germination and pollen fertility of mungbean cultivars PS-10 and PS-16 was investigated. Seeds were pre-soaked in distilled water for 9 hr prior to treatment with EMS at 0.01, 0.02, 0.03 and 0.04% for 6 hr. Seeds were either used to test for germination percentage or sown in the field (Uttar Pradesh, India) for evaluation of pollen fertility. Seed germination and pollen fertility linearly decreased with increasing concentration of EMS. In the control PS-10 showed 96% germination, while PS-16 showed 95% germination. The maximum inhibition of seed germination in PS-10 and PS-16 (18.75 and 25.26%, respectively) was observed with EMS at 0.04%. Pollen fertility in the control was in the range 70-94 and 68-95% for PS-10 and PS-16, respectively. Pollen fertility reduction in PS-10 and PS-16 was maximum at 0.04% EMS 25.53 and 28.42%, respectively (Wani, 2004).

Samiullah et al. (2004) induced mutation in mungbean cultivars K-851 and Pusa Baisakhi by treating with sodium azide at 0.01 and 0.02% for 6 hr. The immediate effects of the mutagen were measured in the M₁ generation. All the treatments reduced seed germination, pollen fertility and survival at maturity. All these parameters, except survival, were dose dependent.

2.2 Chlorophyll mutation:
Albina, xantha and chlorina types of mutations were observed in gamma ray induced populations of ML-26 and T-44 varieties (treating with 30 & 40 KR) by Singh et al. (1979) and the mutants segregated in the ratio of 1(mutant) : 15 (normal) in the M₂ generation.

In several studies, it was shown that gamma rays were more effective than EMS in inducing chlorophyll as well as viable mutations (Jebraj and Marappan, 1981).
Chlorophyll mutations in two varieties (ML-5 and K-851) were studied severally and in combination following treatments with gamma rays and EMS by Bahl and Gupta (1982). Combined treatments (0.2% EMS for 6 hour with 20, 30, 40 & 50 KR gamma rays) produced higher mutation frequencies than individual treatments (EMS 0.2 and 0.4% for 6 hour and gamma rays 20, 30, 40 & 50 KR). Albina and xantha appeared more frequently, relative to other chlorophyll mutations.

Eleven genotypes of *Vigna radiata* and five of *Vigna mungo* were gamma-irradiated with doses ranging from 5 to 80 KR. The frequency of chlorophyll mutations in the M₂ indicated that 30 KR was optimal. The LD₅₀ was 60 KR. Four mungbean mutants released in 1986 yielded 30-40% more than their parents and matured in 55-70 days. In blackgram several early mutants with erect growth habit were induced in local cultivars. They yielded 40-50% more than their parents (Malik, Ali and Sarwar, 1986).

Saini *et al.* (1989) treated dry seeds of *Vigna radiata* cv. Pusa Baisakhi with various ethyl methanesulfonate concentrations for a period of 20 hr. and obtained 5 chlorophyll mutants (alboviridis, albina, virescens, albescens and maculata).

Khan and Siddique, (1993) induced mutations in two mungbean varieties, PS16 and Pusa Baisakhi, by treating seeds with 0.1 to 0.4% EMS, 0.01 to 0.04 MMS and 0.01 to 0.04 sodium azide (SA). Three different types of chlorophyll mutants were observed in the M₂ generation: albina, chlorina and viridis. Chlorophyll mutation frequency increased with increase in concentration of various mutagens. EMS produced the highest frequency of mutations followed by MMS and SA.

Using sodium azide and hydrazine hydrate (HZ), chlorophyll mutations were induced in mung bean (*Vigna radiata*) cv. Asha. The spectrum of chlorophyll mutations consisted of albina, chlorina, virescence, viridis and xantha. Out of these chlorophyll mutations, xantha type was predominant in both the mutagenic treatments. The frequency and spectrum of chlorophyll mutations as well as mutagenic efficiency and effectiveness was the highest at lower doses. HZ was the most efficient and effective mutagen with
respect to the biological damage and high frequency of chlorophyll mutations (Mehraj-ud-din et al. 1999).

2.3 **Morphological mutation:**

Bhatt. *et al.* (1972) reported a giant mutant by treating a variety namely, D-66-26 with 20 KR of gamma rays and multfoliate leaf with nine or more leaflets were observed by Satyanarayan *et al.* (1989) by treating Pant-moong-2 with 40 KR of gamma rays.

Dwivedi and Singh (1985), observed narrow lanceolate leaf mutant by irradiating T44 variety from the 10 KR of gamma irradiation.

U Thong 1 a greengram variety was gamma irradiated with gamma rays at a range of 30-50 KR and twin pod and multfoliate were observed by Lamseejan *et al.* (1983) and in the same way small bright yellow seeds were observed from 20 KR of gamma rays by Singh (1987).

Singh *et al.* (1988) irradiated 200 seeds of *Vigna radiata* cv. T-44 by different doses (5, 10, 20, 30, 40 & 50 KR) of gamma rays and they identified multiracemose inflorescence in the M2 generation from the 40 KR treatment and a significantly increased number of pods compared with the parent. The mutant bred true in the M3 generation also.

Scarlet leaflet margins were reported in a variety of Pak 32 by treating it with 60 KR of gamma rays (Malik *et al.* 1988).


Saini and Mahna (1989) treated dry seeds of *Vigna radiata* cv. Pusa Baisakhi with EMS for 20 hours and obtained three types of morphological mutants namely erectoid, unifoliate and dwarf selected in the M2.
The frequency and range of viable mutations induced by gamma rays, EMS and hydrazine hydrate (HZ) in the $M_2$ were determined after treating dry seeds of the *Vigna radiata* varieties G 65 and PS 16. Mutation frequency was in linear relation to mutagen dose. The frequency and range of mutations were lowest with HZ and highest with EMS. The mutagen resistant variety G 65 gave a lower frequency of mutation than the sensitive PS16. There was a wide range of mutation types. The most frequent were those affecting leaf morphology, plant habit, maturity date and fertility. Some leaf mutants appeared useful for breeding (Khan, 1989).

Seeniah et al. (1990) observed that an extended stigma flower mutant coupled with male sterility in greengram [*Vigna radiata*] from the $M_3$ population of the variety cv. Pant Mung 2 following treatment with 40 KR gamma rays. The petals were only half developed in the fully opened flower hence the stigma was exposed. The anthers were shrunken and contained only non-viable pollen. No pods were set under natural conditions but pod setting was normal, with well-filled seeds, after pollination by male-fertile, normal plants.

To create genetic variability, Mittal et al. (2001) had taken two varieties of greengram (ML-2 & K-851) and subjected to them gamma irradiation (20 KR) following hybridization. They observed 18 different types of morphological variants classified as late, very late, early, tall, dwarf, trailing type plant, tobacco-plant type, vigorous growth, multifoliate, broad leaved, bold seeded, black seeded, less seed in a pod, less number of pods, sterile, empty pods, curved pods and constricted pod in the $M_2$ generation.
2.4 Induced variability for yield attributes

Krishnaswamy et al. (1973) identified some high yielding types from gamma ray irradiated materials of mungbean in M₅ generation. These mutants had increased number of pods and clusters per plant.

Abdul Shakoor et al. (1978) had observed a significant reduction in the number of pods per plant, number of seeds per pod and total yield by a gamma irradiation.

Tickoo and Jain (1980) through their mutation study with different mutagens like EMS, N-nitroso, N-methyl urea hydroxylamine and gamma rays, found to increase in variance for yield and yield contributing traits in the M₂ and M₃ generations. The variance in M₂ was more than in M₃ generation and suggested that effective selection can be made from M₂ generation as such.

Thakre et al. (1980) selected some plants with increased number of pods per plant from gamma ray treated plants of cv. S-8 of mungbean and by selection for three successive generations, 2 mutants were established that gave 25-30% more yield than control or parents.

Ilyas et al. (1980) established some high yielding mutants through gamma ray irradiation in some cultivars of mungbean.

Chaturbedi and Singh (1980) observed different dose effects on different varieties for the characters like number of pods per plant and number of seeds per pod. They isolated mutants from 40 KR treatments in the varieties like Pusa Baisakhi and S-8, which were high yielding in M₂ generation. But significant increase in seed yield per plant was recorded in S-8 in M₃ generation.

Singh and Chaturbedi (1980) obtained some large seeded high yielding mutants by treating the seeds of Pusa Baisakhi and S-8 with various mutagens either separately or in combinations. Highest yield in mutants of Pusa Baisakhi and S-8 were obtained from the chemical mutagen and 40 KR respectively.
Ganguly and Bhaduri (1980) irradiated dry seeds of greengram in X-ray and thermal neutrons and obtained some variants in the M₁ generation which had reduced number of branches and plant yield.

Khan (1982) observed greatest variability in the M₂ generation for yield, number of pods and 100 seed weight in gamma ray irradiated population of mungbean.

Increased variability within treated populations as compared to control is reported for yield and yield components on greengram (Dahiya, 1973; Rajput, 1974; Singh et al., 1979; Verma and Singh, 1983 and Sharma and Haque, 1983).

Khan (1984) treated Vigna radiata cv. PS-16 with 20 KR gamma rays, 0.3% EMS and 0.04% hydrazine hydrate and found that genotypic co-efficient of variation for seeds per pod, 100 seed weight and total grain yield were higher in the M₃ than in the M₂ and suggested that high yielding mutants could be obtained by selection in the M₂.

Verma and Singh (1984) observed in the M₃ generation that the mean value of yield and yield contributing characters were increased for all the dose of gamma rays.

Seth et al. (1986) observed increased in number of branches per plant in M₂ and M₃ generation of greengram over control in mutagen treated plants by gamma ray-induced mutation.

Seeds of the local cultivars 6601, RC71-27 and Pak 22 were gamma-irradiated with doses ranging from 5 to 60 KR to give 74 M₄ lines. Seed yield was positively and significantly correlated with numbers of pods, clusters and branches in all treatments. Numbers of pods and branches, seeds/pod and early maturity were the most important yield components, accounting for 80-93% of variability in yield (Malik et al. 1986).

For field experiments seeds of greengram were irradiated at 60 and 90 KR. In the M₄, 40 lines were early maturing while 32 were high yielding. In the M₆ generation, 7 early maturing and 5 high yielding mutants were selected. The mutant Hy3-60-8 gave the
highest yields and was best adapted to the early rainy season while E3-60-37 was best adapted to the dry season (Vanitvatanalumlog et al. 1986).

Mutation breeding experiments to increase the yield potential of *Vigna radiata* were also described. Hybridization and/or induced mutagenesis produced mutants with larger seeds and 28% higher yield than the most productive cultivar, ML5 (Pawar et al. 1986). Sarwar et al. (1987) treated eight cultivars of mungbean with 8 doses of gamma rays (5-100 KR) and found marked decrease in pod length, number of seeds per pod and 100 seed weight at 40 KR treatment in all varieties. They suggested that doses of 30 and 40 KR might be used for generating useful mutants.

Khan (1987) observed shift in the mean values for yield and number of pods per plant to the positive direction through selection in gamma ray induced mutant populations. Heritability estimates and genetic advance was better at 40 KR than at 20 KR for all the selections.

Rosaih et al. (1987) identified 15 high yielding $M_6$ lines from gamma ray irradiated seeds of mungbean cv. LGG 127 and ML 26-10-3 and found most mutants exceeded the parental mean values for yield per plant and 10 related characters. The mutants showed increased genetic variability and heritability for all the traits except total dry matter at maturity and pod length.

Rajput et al. (1988) isolated 4 high yielding true breeding mutant lines from $M_3$ and onwards from gamma ray irradiated populations of mungbean.

Pande and Raghuvanshi (1988) exposed the mungbean variety K 851 with 3 doses of gamma rays and subsequently with EMS. A true breeding line identified in $M_3$ with increased number of pods per plant, seeds per pod and high yield.
Three quantitative characters were evaluated by Khan (1988) in cv. G 65, a greengram variety, after treatment of seeds with gamma rays and ethyl methanesulfonate (EMS) used either singly or in combination. Mean values for all 3 characters (number of pods, 100-seed weight and seed yield) increased in the M₂ as compared to the control. Total phenotypic variability increased, as did the values of the phenotypic and genotypic coefficients of variation. Estimates of heritability and expected genetic advance for number of pods and 100 seed weight were highest following gamma irradiation and for plant yield following combined treatment. In general, the values of heritability and genetic advance were low for all the characters (Khan, 1988).

Gamma irradiation of the seeds of 3 diverse genotypes of Vigna radiata (H70-6, H70-16 and H70-21) resulted in increased mean values for number of branches/plant in all 3 genotypes in the M₁ and M₂, with 20 KR being the most effective dose. (Seth and Chaudhary, 1989).

Dry seeds of greengram cultivars namely Pusa 105 and Neelalu were gamma irradiated at a range of 10-15 KR doses and variability studies were conducted both in M₂ and M₃ generations. Irradiated populations of Pusa 105 showed significant increase for pods/plant and 100 seed weight while in case of variety Neelalu maximum increase was observed in pods/plant and pods/cluster (Pulivarthi et al. 1989).

Seeds of Vigna sublobata (wild population from Tamil Nadu), Vigna radiata (cv. PS16) and Vigna mungo (cv. T9) were subjected to gamma irradiation (0, 10, 20, 30 and 40 KR) and ethyl methanesulfonate treatments (0, 0.1, 0.2, 0.3 and 0.4%) singly and in combination. Data recorded from the M₁ plant populations on 6 yield components revealed high levels of genetic variance, heritability and genetic advance in most of the traits. Marked variation between treatments and between species was noted (Ignacimuthu et al. 1990).

Tripathy (1990) treated seeds of Dhauli and Khurda Local of greengram with 0.2, 0.4 and 0.6% ethyl methanesulfonate in combination with gamma radiation (5, 10, 15, 20
and 30 KR). In the M₂ a total of 12 characters were recorded and it was found that 30 KR gamma irradiation produced the highest frequency of macromutations. This was followed by 15 KR + 0.6% EMS, 10 KR + 0.4% EMS and 20 KR gamma radiations. Combination treatments of low doses of EMS and gamma radiation have been recommended for inducing mutations in yield components.

Two varieties of greengram namely, Pak-22 and E-54 were irradiated with gamma rays (10, 20, 30, 40, 50, 60, 70 & 80 KR) and fast neutrons (0.8, 1.2, 1.6, 2.0, 2.4, 2.8, 3.2, & 3.6 KR) and significant reduction in pod length and seeds per pod were observed. The number of pods per plant increased at lower doses while other doses had inhibitory effects. (Hassan et al. 1990).

Sumanggono, (1991) irradiated mungbean cultivars Manyar and Walet with several doses of gamma rays and Nuri with fast neutrons and he identified about 164 mungbean mutant lines from the M₅ generation. Four high yielding mutant lines derived from the gamma irradiation of Walet, three lines which showed synchronous maturity as well as larger pods and a greater number of seeds derived from the gamma irradiation of Manyar and a high seed protein content derived from the fast neutron irradiated Nuri.

Singh et al (1991) taken dry seeds of a variety of mungbean cv. T44 and were exposed to gamma rays (5-40 KR), ethyl methane sulfonate (EMS, 0.01-0.05 M), combination treatments (5-40 KR gamma ray doses followed by 0.02 M EMS) and recurrent doses of gamma rays (5-40 KR with further doses in the following generation). They observed mutants in the M₂ generation for the characters like, plant height, plant habit, branching pattern, leaf morphology, venation, pigmentation, peduncle length, pod characters, male sterility, maturity, seed colour and yield. The mutants VR Mra-13, VR Hy-30, VR Sh-16 and VR Bu-3 showed significant increases in pods and seed yield/plant.

Variability and genetic divergence for 8 yield components were studied in 34 micromutants of mungbean and 2 base genotypes obtained by gamma irradiation (10, 20 and 30 KR) and treatment with ethyl methane sulfonate (0.1, 0.2 and 0.3%), singly and in
combination. Primary branches, pods per cluster and clusters per plant showed high heritability with high genetic advance. On the basis of $D_2$ values, micromutants could be grouped into 9 clusters, indicating that mutations are effective in creating genetic divergence. Primary branches, pods per cluster and days to maturity contributed most to the divergence of the micromutants (Sarma and Talukdar, 1991).

Seeds of *Vigna radiata* cv. K851 were exposed to 15 and 20 KR doses of X radiation and/or treated with ethyl methanesulphonate and diethyl sulfate. Variation for pod length, seeds/pod and 100 seed weight was studied in the $M_1$ and $M_2$ generations. All treatments had a deleterious effect on pod length, and most also adversely affected the other 2 traits studied. In the $M_2$, variance within mutagenic treatments due to progenies was significant for all 3 traits in the majority of combined treatments and in some of the individual treatments (Kansagra and Shukla, 1993).

Ahmad and Yaqoob, (1993) exposed dry seeds of 2 mungbean varieties (562-I and MC1) to 5 levels of gamma irradiation (10-50 KRad) to produce variant genotypes for plant height, number of pods/plant, pod length, number of seeds/pod and 1000 seed weight. The analysis of the data recorded on resulting plants grown in the field showed greater variability in all the characters except 1000 seed weight. The highest magnitude of variability was observed in plant height: 54.3% increase over the respective control. The lowest variability was recorded for pod length.

Baruah and Talukdar (1993) reported thirty four micromutants in the M6 generation from the two base genotypes (AAU-34 & AAU-39) by treating with gamma rays and EMS singly or in combination and evaluated them for considering 9 yield components and physiological traits. They observed 10 AAU-34 mutants those produced at least 20% higher seed yield than the parent.

Eleven selection indices were formulated using 3 yield components which showed positive correlation with yield. Genetic advance and relative efficiency of these indices were determined in studies with the $M_3$ of 2 *Vigna radiata* cultivars, PIMS and Pusa Baisaki, following treatment with gamma radiation or ethyl methanesulphonate (EMS).
The index consisting of number of pods, and pod and seed yield per plant showed the highest genetic advance and the highest relative efficiency. The index values were highest for all the selections when the index giving highest genetic advance was considered. Selections derived from EMS treatments generally gave higher index values than selections derived from gamma irradiation in both cultivars (Patil et al. 1994).

Dry seeds (10% moisture content) of Pusa Baisakhi, a standard variety of mungbean were treated with 10, 20, 30 and 40 KR gamma rays. Pods/plant increased with increased dosage but the seeds/pod showed a corresponding decrease. On the whole, the yield of seed per plant was approximately equal to that of control except at the 30 KR treatment where yield surpassed that of control. Plants subjected to this dose exhibited more pods/plant but less seeds/pod. Doses above 40 KR caused deleterious effects in >50% of plants (Sarkar et al. 1996).

The dry seeds of mung bean [Vigna radiata], varieties ML5 and K851 (with 9.80% and 9.55% moisture content, respectively), were treated with (1) acute doses of gamma rays (200, 300, 400 and 500 Gy), (2) EMS (0.2% and 0.4% for 6 hr and 12 hr) and (3) gamma rays (100, 200, 300 and 400 Gy) followed by 0.2% EMS for 6 hr. Some of the mutants with higher number of pods per plant and higher yield were observed in M5 and M6 generations. Superior mutants were advanced up to the M8 generation. Four promising mutants (MUM1-4) were developed in 1982. Yield trials were conducted for 4 generations during 1983-1989. All mutants out-yielded over their parents and control varieties Pusa Baisakhi and PS16 in the summer as well as in the rainy season, except MUM2 in the summer of 1983, and MUM4 in kharif 1984 and the summer 1985. MUM1, MUM2 and MUM3 were highly tolerant of MYMV and were synchronous in maturity. MUM4 was only moderately tolerant (Gupta et al. 1996).

Dry seeds of Phaseolous radiatus [Vigna radiata] cultivars Dhauli and Sujata were pretreated with thyroxine, digitonine and colchicine, before treatment with 0.2% solutions of ethyl methanesulfonate and sodium azide. Seeds were sown in 1986, and M1 to M5 generations selected for variants with higher pod number and desirable agronomic
characteristics during 1986-88. A total of 23 mutants were selected and evaluated for 9 yield components during 1988-92. Among the mutant lines, there were significant increases in pod number and length, and decreases in days to maturity. Overall, OUM11-5 was ranked as the best mutant phenotype, followed by OUM11-2, OUM11-4, OUM11-6 and OUM14-1 (Sahu and Patra, 1997).

Sharma (1998) took the seeds of three greengram genotypes (T-44, AAU-34, AAU-39) and soaked them for 12 hours and exposed to 10 KRad gamma rays and treated with 0.1% of EMS for 6 hours. He treated half of the M1 seeds with half of the previous dose for inducing recurrent mutations. Different responses of the treatments were observed for all the characters. On the whole, gamma ray induced higher mean performance and variability than EMS.

The seeds of 4 mungbean genotypes, namely Kanti, Mubarik, Mosk-1 and 312, were irradiated from the $^{60}$Co source at 2000 rads per minute at 20, 30, 40 and 50 KR to induce mutation. The M2 seeds along with their control were grown in the field in Gazipur, Bangladesh and observed the spectrum of mutation for 1000-seed weight, yield and protein content. The mean grain protein content of mutants of all the genotypes increased marginally over the parents. A number of plants were identified with high yield along with high protein content. A wide variation in the electrophoreogram of total protein was also observed (Chakraborty et al. 1998).

Mohanty et al. (1998) reported two useful mutants, which were induced from locally adapted greengram cv. Kalamung by gamma irradiation. The small podded mutants had the highest pods/plant and seed yield/plant whereas, the large podded mutant was superior to its parents in respect of seeds/pod with higher pod length and 100 seed weight.

Two varieties of mungbean were treated with ethyl methanesulfonate (EMS) (0.1 and 0.2%), N-methyl-N-nitrosourea (NMU; 0.01 and 0.02%), hydroxylamine (0.06 and
0.07%) and gamma rays (30 and 40 KR). In the M₂ and M₃ observations on six characters were recorded for overall variance, interfamily variance and character means. All mutagen doses induced significant variability. Mean values showed a negative shift for most of the characters in the M₂. Plants with desirable attributes were selected from M₂ families showing higher CV and mean values than the highest corresponding values from the respective control group of families. Selection in the M₂ was effective as mean values in the M₁ shifted in positive directions and in the M₃ interfamily variances increased over corresponding M₂ treatments. In the M₃, along with the positive shift of mean values, both interfamily and overall variances were still significantly higher than the respective control values indicating scope for further selection and improvement of characters governed by polygenes (Tickoo and Chandra, 1999).

Srinivas et al. (2000) irradiated F₂ seeds from the crosses Vigna radiata × Vigna radiata (Wild), Vigna radiata (Wild) × Vigna radiata, Vigna mungo × Vigna mungo (Wild) and Vigna mungo (Wild) × Vigna mungo with 10, 20, 50 and 70 KR of gamma rays and found quantitative responses to irradiation were only in 100 seed weight M₁ plants. Mutation was detected in quantitative traits including early maturity.

Singh et al. (2001) studied the extent of genetic variation in the characters of mungbean cv. PS-16 following mutagenesis with gamma rays (20, 30 and 40 KR) ethyl methane sulfonate (0.05, 0.1, 0.2 and 0.3%) and epichlorohydrin (0.1, 0.2, 0.3 and 0.4%) for 6 rows and found that number of pods per plant, seeds per pod, 100 seed weight and yield increased significantly after mutation. The induced mutation was higher in treated populations than the control. Estimates of genetic parameters showed higher values for phenotypic and genotypic co-efficient of variation for number of pods per plant. Number of seeds per pod and yield with the highest variation record for yield. Heritability and genetic advance estimates increased significantly after treatment for number of pods per plant, number of seeds per pod and 100 seed weight.

The effects of induced mutation by gamma irradiation (100, 200, 300, 400 and 500 Gy) on various agronomic traits of five mungbean cultivars (NM-19-19, M-22-24,
M-29-37, M-38-54 and M-133-100) were studied by D.I. Khan, Pakistan, during 1990-92. A wide range of variability was observed for all the characters except plant height. The genotype × gamma radiation interaction was highly significant for days to 50% flowering, days to maturity, number of branches and number of clusters, and not significant for plant height and number of pods (Muhammad and Bashir, 2003).

Samiullah et al. (2003) studied the effect of MMS, applied to seeds at concentrations of 0.01, 0.02, 0.03, and 0.04%, on greengram cv. Pusa Baisakhi. MMS induced genetic variability in plant height, fertile branches/plant, pods/plant and total plant yield was observed in the M2 generation. Plant height increased with increasing levels of MMS, while fertile branches per plant, pods per plant, and total yield per plant showed both higher and lower values compared with the control upon treatment with increasing levels of MMS. The highest values for genotypic (28.74%) and phenotypic coefficient of variation (34.22%) were recorded for fertile branches per plant at 0.03% MMS. The highest heritability and genetic advance for fertile branches per plant (70.52 and 63.71%, respectively) and pods per plant (67.91 and 28.43%, respectively) were recorded at 0.03% MMS.

Baisakh et al (2004) isolated ten useful mutants by gamma rays treatment in Nayagarh local and Berhampur local, the locally adopted mung bean cultivars of Orissa, India. After sufficient generation advancement (M8 generation) they were evaluated with their respective parents and other standard cultivars in (rabi) season. Some mutants recorded higher yield than their respective parents and the mutant of Nayagarh brown N 40-8-1 was the highest yielder among all entries tested with a yield of 708.3 kg/ha. Mutant N 40-8-1 had also higher number of pods per plant (8.6) and larger pod size (6.6 cm) compared to the best controls ¹ PDM 54 and Dhauli.

The genetic parameters increased in the M2 and M3 generations. Increase in positive correlations between the number of fertile branches and pods, the number of fertile branches and total plant yield, and the number of pods and total plant yield was observed under the mutagen treatments. The mutagen treatments could alter the mean
values and create additional genetic variation for quantitative traits (Samiullah et al. 2004).

Green gram cv. Pusa Vishal were treated with gamma-rays (15, 30, 45 and 60 KR), EMS (0.15, 0.30, 0.45 and 0.60%) and nitrosoguanidine (NG; 0.005, 0.010, 0.015 and 0.020%). Twelve selected M$_2$ plant progenies from each of the 12 mutagenic treatments along with the parent were evaluated in M$_3$. Four highest yielding M$_3$ progenies from each treatment along with the parent were evaluated for yield and eight component traits in the M$_4$ generation. In the M$_3$ generation, 57 of the 144 progenies produced significantly higher yield than the parent and EMS treatments produced higher number of such high yielding progenies. In the M$_4$ generation, 36 of the 48 cultures showed superiority over the parent cultivar in one or more traits. High frequency of positive mutations was observed for traits 100 seed weight, yield, clusters per plant and early maturity. Moreover, EMS treatments produced higher number of superior mutants (44.7%) in different traits than gamma rays and NG treatments. Among the mutagenic treatments, the frequency of high yielding progenies/cultures in the M$_3$ and M$_4$ generations were higher in gamma rays (30 or 45 KR), EMS (0.30 or 0.45%) and NG (0.01%) treatments (Mishra and Momin, 2004).

Green gram cv. Pusa Vishal was given mutagenic treatments with 4 doses each of gamma rays (15, 30, 45 and 60 KR), ethyl methanesulfonate (0.15, 0.30, 0.45 and 0.60%) and N-methyl-N-nitrosoguanidine (0.005, 0.010, 0.015 and 0.020%). In the M$_4$ generation, 48 selected mutant cultures along with the parent were evaluated for 9 quantitative traits including yield. The range of variation among the mutant cultures was quite wide, both in positive and negative directions compared to the parent cultivar, showing that mutagenic treatments were effective in inducing micromutations in these polygenic traits. Thus, induction of micromutations in these 3 traits appear to be independent of each other and selection for any one of these traits in mutant populations may not affect the other 2 traits adversely and can be effective in the identification of mutant lines with higher yield than the parent (Momim and Mishra, 2004).
Chapter – 3

MATERIALS AND METHODS
MATERIALS AND METHODS

3.1 Materials

Two promising greengram genotypes namely, PDM-84-139 and B-1 were chosen as the experimental materials to study the effect of the physical mutagen on the induction of variability in biometrical characters.

The salient features of the genotypes PDM-84-139 and B-1 are furnished below.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>PDM-84-139</th>
<th>B 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Source</td>
<td>Indian Institute of Pulse Research (IIPR), Kanpur</td>
<td>Pulses and Oilseed Research Station (PORS), Berhampore, West Bengal</td>
</tr>
<tr>
<td>2. Plant height (cm)</td>
<td>41.38</td>
<td>59.2</td>
</tr>
<tr>
<td>3. Number of branches per plant</td>
<td>2.25</td>
<td>2.4</td>
</tr>
<tr>
<td>4. Number of pods per plant</td>
<td>43.25</td>
<td>43.2</td>
</tr>
<tr>
<td>5. Cluster per plant</td>
<td>9.4</td>
<td>9.6</td>
</tr>
<tr>
<td>6. Pod length (cm)</td>
<td>6.5</td>
<td>6.9</td>
</tr>
<tr>
<td>7. Number of seeds per pod</td>
<td>9.8</td>
<td>11</td>
</tr>
<tr>
<td>8. 100 seed weight (g)</td>
<td>3.4</td>
<td>2.74</td>
</tr>
<tr>
<td>9. Seed yield per plant (g)</td>
<td>10</td>
<td>9.86</td>
</tr>
<tr>
<td>10. Duration (days)</td>
<td>71</td>
<td>82</td>
</tr>
</tbody>
</table>

Pure seeds of the genotypes PDM-84-139 and B-1 obtained from Indian Institute of Pulse Research (IIPR), Kanpur, UP and Pulses and Oilseeds Research Station (PORS), Berhampore, West Bengal.
3.2 **Location of Trials:**

The trails relating to the present study on induced mutagenesis in greengram was carried out at the Regional Research Station, New Alluvial Zone, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal during 2002 – 2005.

The Regional Research Station (New Alluvial Zone), Experimental Farm at Gayeshpur is situated at 23°N latitude and 89°E longitude at an elevation of 9.75 meters above mean sea level.

3.3 **Soil type of the experimental field:**

The soil is typical Gangetic alluvial soil (Entisol), having sandy loam texture with good drainage facilities. The physico chemical properties of the experimental soil have been presented in Table 1.

**Table 1 : Physico-chemical properties of the experimental soil**

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textural class sandy loam</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>51.7%</td>
</tr>
<tr>
<td>Silt</td>
<td>31.4%</td>
</tr>
<tr>
<td>Clay</td>
<td>16.9%</td>
</tr>
<tr>
<td>Total N</td>
<td>0.059%</td>
</tr>
<tr>
<td>Available P₂O₅</td>
<td>52.00 kg/ha</td>
</tr>
<tr>
<td>Available K₂O</td>
<td>207.48 kg/ha</td>
</tr>
<tr>
<td>pH</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*Source: Status Report NAZ, Nadia, West Bengal (Year 1994)*

3.4 **Climate :**

The seasons of this region can be broadly classified into three, viz.

a) dry and warm (March to May)
b) warm and humid (June to October) and

c) dry and cool (November to February).

The climate of Gayeshpur is of sub-tropical humid in nature. The lowest average minimum temperature is around 8°C and it usually occurs in January and the mean maximum temperature does not exceed 40°C in April – May. This region receives an average annual rainfall of 1400 mm, mostly precipitated during June to September, with occasional winter rain due to nor-wester (Kalbaisakhi). Above all, the climate is of monsoon type. Relative Humidity (RH) range (98 – 65%) is very high during rainy season and moderate during other season. There is wide fluctuation of relative humidity during the year. Some mists is seen during September to February. There is bright sunshine throughout the year except rainy season.
Table 2: Meteorological observations during the period of experiments

**Meteorological data:** The recorded meteorological data have been presented in Table 2.

<table>
<thead>
<tr>
<th>Month</th>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
<th>Bright sunshine hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td><strong>Year 2002</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>25.65</td>
<td>32.4</td>
<td>22.12</td>
<td>96.81</td>
</tr>
<tr>
<td>November</td>
<td>38.7</td>
<td>29.89</td>
<td>17.6</td>
<td>98.5</td>
</tr>
<tr>
<td>December</td>
<td>0</td>
<td>27.41</td>
<td>12.44</td>
<td>99.77</td>
</tr>
<tr>
<td><strong>Year 2003</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>0.0</td>
<td>23.7</td>
<td>9.2</td>
<td>99.65</td>
</tr>
<tr>
<td>February</td>
<td>0.8</td>
<td>29.2</td>
<td>15.9</td>
<td>98.04</td>
</tr>
<tr>
<td>March</td>
<td>61.8</td>
<td>32.0</td>
<td>19.4</td>
<td>95.10</td>
</tr>
<tr>
<td>April</td>
<td>6.0</td>
<td>36.5</td>
<td>24.7</td>
<td>92.03</td>
</tr>
<tr>
<td>May</td>
<td>81.4</td>
<td>36.5</td>
<td>24.9</td>
<td>91.23</td>
</tr>
<tr>
<td>June</td>
<td>361.3</td>
<td>34.8</td>
<td>24.9</td>
<td>93.43</td>
</tr>
<tr>
<td>July</td>
<td>292.2</td>
<td>33.4</td>
<td>25.0</td>
<td>97.35</td>
</tr>
<tr>
<td>August</td>
<td>155.7</td>
<td>33.4</td>
<td>25.0</td>
<td>97.65</td>
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<tr>
<td>September</td>
<td>162.0</td>
<td>33.4</td>
<td>25.6</td>
<td>98.53</td>
</tr>
<tr>
<td>October</td>
<td>197.9</td>
<td>31.87</td>
<td>23.87</td>
<td>99.03</td>
</tr>
<tr>
<td>November</td>
<td>22.6</td>
<td>30.54</td>
<td>16.69</td>
<td>99.00</td>
</tr>
<tr>
<td><strong>Year 2004</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>0.0</td>
<td>24.23</td>
<td>11.49</td>
<td>98.58</td>
</tr>
<tr>
<td>February</td>
<td>0.0</td>
<td>29.61</td>
<td>14.31</td>
<td>96.55</td>
</tr>
<tr>
<td>March</td>
<td>1.8</td>
<td>35.31</td>
<td>20.69</td>
<td>94.00</td>
</tr>
<tr>
<td>April</td>
<td>112.0</td>
<td>36.18</td>
<td>24.00</td>
<td>93.70</td>
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<tr>
<td>May</td>
<td>104.6</td>
<td>37.67</td>
<td>25.73</td>
<td>89.26</td>
</tr>
<tr>
<td>June</td>
<td>320.5</td>
<td>34.67</td>
<td>25.77</td>
<td>95.33</td>
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<tr>
<td>July</td>
<td>229.9</td>
<td>33.45</td>
<td>25.69</td>
<td>90.13</td>
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<td>August</td>
<td>293.5</td>
<td>32.93</td>
<td>25.66</td>
<td>98.52</td>
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<td>September</td>
<td>425.3</td>
<td>32.75</td>
<td>24.83</td>
<td>98.07</td>
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<tr>
<td>October</td>
<td>206.3</td>
<td>32.02</td>
<td>21.78</td>
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<tr>
<td>November</td>
<td>0.0</td>
<td>30.53</td>
<td>16.64</td>
<td>98.33</td>
</tr>
<tr>
<td>December</td>
<td>0.0</td>
<td>27.66</td>
<td>13.92</td>
<td>98.87</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>12.05</td>
<td>98.77</td>
</tr>
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<td>30.26</td>
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</tr>
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<td>21.18</td>
<td>94.97</td>
</tr>
<tr>
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<td>93.23</td>
</tr>
<tr>
<td>May</td>
<td>37.6</td>
<td>37.16</td>
<td>25.66</td>
<td>92.16</td>
</tr>
<tr>
<td>June</td>
<td>239.9</td>
<td>36.88</td>
<td>26.83</td>
<td>93.03</td>
</tr>
</tbody>
</table>

**Source:** AICRP on Meteorology, B.C.K.V.; Kalyani, Nadia, West Bengal
3.5 Mutagen and Methods of treatment:

3.5.1 Mutagen

<table>
<thead>
<tr>
<th>Mutagen</th>
<th>Source</th>
<th>Method of treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma rays</td>
<td>Gamma ray chamber from CO 60 source</td>
<td>Sun dried seeds were taken in a number of Petri dishes as per the number of the treatments. These were then kept at different distances from the source in order to adjust the varying doses by adjusting the exposure timing.</td>
</tr>
</tbody>
</table>

3.5.2 METHODS:

Gamma rays

In the course of present study 100 well filled dry seeds of the said two varieties of greengram namely PDM-84-139 and B 1 were treated with 30, 50 and 70 KR doses of gamma rays as follows and 100 seeds were also kept as control:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Type of mutagen used</th>
<th>Dosage of mutagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 1</td>
<td>Control</td>
<td>0 krad</td>
</tr>
<tr>
<td></td>
<td>Gamma rays</td>
<td>30 krad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 krad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70 krad</td>
</tr>
<tr>
<td>PDM-84-139</td>
<td>Control</td>
<td>0 krad</td>
</tr>
<tr>
<td></td>
<td>Gamma rays</td>
<td>30 krad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 krad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70 krad</td>
</tr>
</tbody>
</table>

Total number of treatments = 6 + 2
3.6 M₁ generation:

Treated seeds of each treatment along with control were sown separately to raise the M₁ generation in the Regional Research Station, New Alluvial Zone, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal. The inter row spacing was 30 cm and the seeds were sown at 10 cm apart. The percentage of seed germination and seedling survival rate were observed at the seedling stage. Besides these, observation on biological yield (g), plant height (cm), number of branches, pod number per plant, pod length (cm), seeds per pod, 100 seed weight (g), seed yield per plant (g) and Harvest Index (H.I.) was calculated based on the biological yield and economic yield. Observations were made on randomly taken 15 plants for their morphological abnormalities in M₁ generation for each treatment. Single plants were harvested individually from each treatment in the M₁ generation and grown as plant to row progenies as M₂ generation in RBD design with three replications.

3.7 M₂ generation:

Fifteen normal looking plants from each of the treatment of both variety cv. PDM-84-139 and cv. B-1 with their performance either closely or better than control with respect to yield and yield contributing parameters were selected for growing in the M₂ generation. In this generation, 30 seeds from each of the plant were used to raise the M₂ generation and the harvest of M₂ were done on single plant basis. The suspected mutant plants were harvested on single plant basis and carried forward to M₃ generation for analysis of the suspected mutants. During the entire growth period from germination to maturity plant population were examined for desirable variation in characters like synchronous maturity, higher yield etc. Mutation analysis was done in M₂ generation. Superior plants for various characters were identified from each progeny. The frequency of chlorophyll mutation and spectrum of mutation was counted in M₂ generation at seedling stage and other mutant at maturity. The mean, variance, co-efficient of variation and heritability estimates were worked out on randomly taken 75 M₂ plants in each of the treatments. Based on mean performance, the best plants in each family were selected.
3.8 **M₃ generation:**

These selected individual plants were grown as plant to row progeny in M₃ generation in three replications with spacing of 30 cm and 10 cm between rows and plant respectively. Five plants were selected for taking observation on quantitative characters viz. biological yield (gm), plant height (cm), number of branches, pod number per plant, cluster number per plant, pod length (cm), seeds per pod, 100 seed weight (gm), seed yield per plant (gm), and H.I. The data were subjected to estimate to various variability parameters statistically. Following observations were recorded from randomly taken five plants and the mean values for each character were considered for statistical analysis.

3.9 **Biometrical parameters:**

3.9.1 **Biological yield (g):**

Immediate after harvest of the crop prior to threshing individual plant weight was recorded that means it is total yield of dry plant and seeds of a plant after drying.

3.9.2 **Plant height (cm):**

Just before harvesting, the plant height was measured from the plant base upto the apex.

3.9.3 **Number of branches:**

Data on branches per plant were taken at the time of harvesting. Plants were randomly taken excluding the border lines for recording the number branches in each treatment.

3.9.4 **Pod number per plant:**

The number of productive pods were counted after harvesting in M₁, M₂ and M₃ generations.

3.9.5 **Cluster number per plant:**

Data on pod cluster per plant were counted that were used to study the variants from control and among the mutants.
3.9.6 Pod length (cm):
Length of five pods from each plant were measured and mean value for each plant was calculated and expressed as pod length.

3.9.7 Number of seeds per pod:
The five pods of each plant were taken for threshing. The number of seeds per pod was then recorded. The mean was calculated for each plant.

3.9.8 100 seed weight (g):
100 healthy grains per plant were weighed in grams and record was undertaken.

3.9.9 Seed yield per plant (g):
After threshing the grains were weighed and the yield of each plant was recorded in grams.

3.9.10 Harvest Index:
It is the ratio of total economic yield and biological yield of a plant according to Donald and Hamblin (1976).

3.9.11 Statistical Analysis
Mean: Mean is defined as the sum of all observations in a sample divided by their number (Singh and Narayan, 1993). It is denoted by $X$ and calculated as follows –

$$X = \frac{\Sigma X}{N}$$

Where $\Sigma = \text{Summation}$

$X = \text{An observation}$

$N = \text{Number of observation in a sample}$

Critical Difference:
In order to compare the means of various entries, we require to calculate the critical difference (C.D.) value by the following formula:

$$C.D. = S.E. \times 't'$$
Where, S.E. is standard error of the difference of the treatment means to be compared and is equal to
\[ S.E. = (2 \text{ MSe}/r)^{1/2} \]
With MSe as error mean sum of square and \( r \) as the number of replications and \( 't' \) is the tabulated value at 55 or 1% level of significance for the degree of freedom of error mean square.
Thus, \[ \text{C.D.} = (2 \text{ MSe}/r)^{1/2} \times 't' \]

**Co-efficient of variation:** The co-efficient of variation (C.V.) being a unitless measurement, is a good basis for comparing the extent of variation between different characters with different scales.

\[
\frac{\text{SD}}{\bar{x}} \times 100
\]

Where, S.D. = Standard deviation
\[ \bar{x} = \text{Grand Mean} \]

**Component of variance:**
Considering that all the varieties tested here were genetically uniform, the expected mean sum of squares for error, \( E(\text{MSe}) \) i.e. \( \sigma^2e \), will be purely a random environmental variance. The mean sum of squares between varieties will consist of the variances

I. attributable to varietal differences i.e. genotypic differences and

II. due to environmental variation among individuals of each genotype

Thus the expected mean sum of squares will be as follows:
\[ E(\text{MSe}) = \sigma^2e \]
\[ E(\text{MSv}) = \sigma^2e + r \sigma^2g \]

Therefore \[ \sigma^2g = \frac{\text{MSv} - \text{MSe}}{r} \]
Thus, the genotypic variance being $\sigma^2_g$ and the environmental variance as $\sigma^2_e$, the phenotypic variance i.e. $\sigma^2_p$ will be equal to $\sigma^2_g + \sigma^2_e$

i.e. $\sigma^2_p = \sigma^2_g + \sigma^2_e$

**Coefficient of variation (Burton, 1952)**

Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) were computed by using the following formulae,

\[
PCV \, (\%) = \frac{\sqrt{\sigma^2_p}}{\bar{x}} \times 100
\]

\[
GCV \, (\%) = \frac{\sqrt{\sigma^2_g}}{\bar{x}} \times 100
\]

Where,

$\sigma^2_p$ - phenotypic variance

$\sigma^2_g$ - genotypic variance

$\bar{x}$ - grand mean

**Heritability**

Heritability in broad sense was computed for each character using the following formula (Lush, 1940)

\[
\text{Heritability} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100
\]

Heritability was classified as follows (Robinson, 1966)

- Above 60 per cent - high
- 30 to 60 per cent - moderate
- Below 30 per cent - low
Genetic advance

Genetic advance for a particular trait was estimated adopting the method as suggested by Johnson et al. (1955a).

\[ GA = h^2 \times \sigma_{ph} \times K \]

Where,
- \( h^2 \) - heritability
- \( \sigma_{ph} \) - phenotypic standard deviation
- \( K \) - selection differential (2.06) at 5 per cent selection intensity

Genetic advance as percentage of mean \[ = \frac{GA}{\text{General mean}} \times 100 \]

Genetic advance was classified as follows (Robinson, 1966)
- Above 20 per cent - high
- 10 to 20 per cent - moderate
- below 10 per cent - low
RESULTS AND DISCUSSION

4.1 M₁ generation:

4.1.1 Germination and survival of two varieties in mungbean

Germination percentage was found to be progressively reduced with increasing doses of gamma rays in both the varieties (Table 3). There was reduction in germination in 70 KR treatment in PDM-84-139 and other doses of KR showed less reduction in germination, similarly in case of genotype B-1 maximum reduction in germination was observed at 70 KR dose of gamma rays compared to the remaining doses. This finding were in agreement of earlier findings of Singh and Chaturbedi (1980). Linear reduction in survival percentage with increasing doses of gamma rays at maturity was observed in both the varieties. In case of PDM-84-139, higher doses of gamma rays i.e. 70 KR caused less survival (35%) in M₁ as compared to other gamma ray treatment similarly in B-1 same phenomenon was noticed and here also 70 KR doses of gamma rays exhibited minimum survival (24%) of M₁ plants. The data on survival of M₁ plants showed more or less similar trend like that of germination. These findings in respect of dose dependent reduction in survival were in conformity with earlier reports of Krishna Swami and Rathinam (1980).

Table 3: Germination and survival of dry seeds of two mungbean cultivars at different doses of gamma irradiation

<table>
<thead>
<tr>
<th>Variety</th>
<th>Treatment</th>
<th>Number of seeds sown</th>
<th>Germination percentage</th>
<th>Survival percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDM-84-139</td>
<td>Control</td>
<td>100</td>
<td>94.5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>30 KR</td>
<td>100</td>
<td>76</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>50 KR</td>
<td>100</td>
<td>64</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>70 KR</td>
<td>100</td>
<td>49</td>
<td>35</td>
</tr>
<tr>
<td>B-1</td>
<td>Control</td>
<td>100</td>
<td>95.2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>30 KR</td>
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<td>85</td>
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<td>50 KR</td>
<td>100</td>
<td>76</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>70 KR</td>
<td>100</td>
<td>63</td>
<td>28</td>
</tr>
</tbody>
</table>
4.2 Induced variability for polygenic traits in M₁ generation:

4.2.1 Biological yield (g):

From the mean data (Table 4) it was observed that a considerable increase in biological yield over the control at most of the treatments in genotypes B 1. A shift towards increased biological yield was maximum (38.53 g) at 30KR gamma rays in B-1 and it also showed highest range (25.00 – 60.00) and variance (72.98). The CV for all the treatments increased over control of this genotype. 70 KR doses registered maximum values of GCV (22.74), PCV (24.04), heritability (0.895) along with genetic advance as percentage of mean (44.30%).

In PDM-84-139, a shift towards increased biological yield was maximum (36.87) at 30 KR dose of gamma rays and afterwards negative shift was realized in 50 & 70 KR doses. 30 KR gamma rays showed maximum range (29.00 – 49.00), CV (18.13), GCV (19.17), PCV (19.32), heritability (0.984) and genetic advance (39.16).

Analysis of variance results of M₁ data (Table 5) shows that 30 KR mutagen dose produced higher amount of biological yield than any other doses. Moreover no significant mean effect was observed due to varying genotypes. No significant interaction between genotype and dose was also indicated.

4.2.2 Plant height (cm):

In B-1 a shift towards reduced plant height was maximum (46.13 cm) at 30 KR treatment of gamma rays as compared to control (Table 5) whereas in PDM-84-139 it was maximum at 70 KR dose (33.07 cm). The maximum range was observed at 50 KR dose (37.00-62.00) in B-1 whereas in PDM-84-139 it was found at 30 KR dose (28.00-42.00). In both the varieties 30 KR dose showed maximum variance i.e. 91.98 and 19.57. In general, the CV among treated population was higher than the control population in both the varieties.

Maximum GCV (15.37), PCV (15.59), heritability (0.971) was observed at 50 KR dose of gamma rays whereas 30 KR dose produced maximum GA (44.00) in B-1 while,
Table 4: Mean, range, variance, GCV, PCV, \( h^2 \) and expected Genetic Advance for biological yield (g) in M₁ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>( h^2 )</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0</td>
<td>28.60</td>
<td>25.00-32.00</td>
<td>4.54</td>
<td>7.46</td>
<td>7.51</td>
<td>7.82</td>
<td>0.923</td>
<td>14.86</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>38.53</td>
<td>25.00-60.00</td>
<td>72.98</td>
<td>22.17</td>
<td>20.79</td>
<td>22.69</td>
<td>0.840</td>
<td>39.24</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>30.47</td>
<td>20.00-40.00</td>
<td>23.27</td>
<td>15.83</td>
<td>15.51</td>
<td>16.50</td>
<td>0.884</td>
<td>30.02</td>
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<td></td>
<td>70</td>
<td>31.40</td>
<td>25.00-50.00</td>
<td>50.97</td>
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<td>22.74</td>
<td>24.04</td>
<td>0.895</td>
<td>44.30</td>
</tr>
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<td>28.00-42.00</td>
<td>16.52</td>
<td>12.07</td>
<td>12.50</td>
<td>12.75</td>
<td>0.96</td>
<td>25.22</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>36.87</td>
<td>29.00-49.00</td>
<td>44.70</td>
<td>18.13</td>
<td>19.17</td>
<td>19.32</td>
<td>0.984</td>
<td>39.16</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>30.80</td>
<td>25.00-39.00</td>
<td>12.60</td>
<td>11.52</td>
<td>11.08</td>
<td>11.91</td>
<td>0.865</td>
<td>21.23</td>
</tr>
<tr>
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<td>70</td>
<td>28.53</td>
<td>20.00-41.00</td>
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<td>17.57</td>
<td>16.75</td>
<td>18.36</td>
<td>0.832</td>
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<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>( h^2 )</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>-</td>
<td>32.25</td>
<td>20.00-60.00</td>
<td>50.43</td>
<td>22.02</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDM-84-139</td>
<td>-</td>
<td>32.47</td>
<td>20.00-49.00</td>
<td>33.41</td>
<td>17.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 0 31.13\(^b\) 25.00-42.00 16.81 13.17
- 30 37.70\(^a\) 25.00-60.00 57.53 20.12
- 50 30.63\(^b\) 20.00-40.00 17.34 13.59
- 70 29.97\(^b\) 20.00-50.00 38.86 20.80

**Overall**

- 32.36 20.00-60.00 41.58 19.93 9.70 10.06 0.930 19.28

**Source**

<table>
<thead>
<tr>
<th>Source</th>
<th>SE (m)</th>
<th>CD (0.05)</th>
</tr>
</thead>
<tbody>
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<td>Genotype</td>
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<td>NS</td>
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<tr>
<td>Dose</td>
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<td>2.98</td>
</tr>
<tr>
<td>Interaction</td>
<td>1.39</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 5: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for plant height (cm) in $M_1$ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0</td>
<td>55.53</td>
<td>48.00-63.00</td>
<td>22.41</td>
<td>8.52</td>
<td>8.94</td>
<td>8.99</td>
<td>0.989</td>
<td>10.18</td>
</tr>
<tr>
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<td>30</td>
<td>46.13</td>
<td>32.00-61.00</td>
<td>91.98</td>
<td>20.79</td>
<td>9.22</td>
<td>13.35</td>
<td>0.477</td>
<td>44.00</td>
</tr>
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<td></td>
<td>50</td>
<td>47.27</td>
<td>37.00-62.00</td>
<td>50.07</td>
<td>14.97</td>
<td>15.37</td>
<td>15.59</td>
<td>0.971</td>
<td>31.10</td>
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<td></td>
<td>70</td>
<td>49.27</td>
<td>42.00-59.00</td>
<td>28.78</td>
<td>10.89</td>
<td>11.27</td>
<td>11.50</td>
<td>0.960</td>
<td>22.73</td>
</tr>
<tr>
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<td>35.00-42.00</td>
<td>3.90</td>
<td>5.09</td>
<td>5.21</td>
<td>5.36</td>
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<td>28.00-42.00</td>
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<td>12.72</td>
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<td>30.00-42.00</td>
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<td>7.20</td>
<td>8.29</td>
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<td>5.97</td>
<td>6.37</td>
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</table>

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>-</td>
<td>49.55</td>
<td>32.00-63.00</td>
<td>59.27</td>
<td>15.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDM-84-139</td>
<td>-</td>
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<td>28.00-42.00</td>
<td>13.45</td>
<td>10.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>47.16</td>
<td>35.00-63.00</td>
<td>85.17</td>
<td>19.57</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>41.57</td>
<td>28.00-61.00</td>
<td>75.43</td>
<td>20.89</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>50</td>
<td>40.77</td>
<td>30.00-62.00</td>
<td>71.50</td>
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<tr>
<td></td>
<td>70</td>
<td>41.17</td>
<td>28.00-59.00</td>
<td>83.73</td>
<td>22.23</td>
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<td></td>
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<tr>
<td>Overall</td>
<td>-</td>
<td>42.67</td>
<td>28.00-63.00</td>
<td>83.85</td>
<td>21.46</td>
<td>22.63</td>
<td>24.53</td>
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<td>4.52</td>
</tr>
<tr>
<td>Interaction</td>
<td>2.11</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan’s test
in PDM-84-139, GCV (12.46), PCV (12.72), heritability (0.961) as well as genetic advance as percentage of mean were maximum at 30 KR dose.

From the analysis of variance it was observed that 0 KR (control) dose increased plant height significantly as compared to all other treatments. Genotype B-1 exhibited higher plant height than PDM-84-139 and there was no significant interaction between genotype and dose in this regard.

Sarkar et al. (1996) observed this type of linearity in reduction of plant height in greengram with increase in gamma ray doses.

4.2.3 Branch number per plant:

All the treatments recorded (Table 6) more number of branches (2.13) and they shifted in the positive direction of control up to 70 KR in B-1 and the range being 2.00 – 5.00 and CV (33.69%) were maximum when treated with 30 KR dose. But in case of PDM-84-139 reduction in number of branches were observed at 70 KR dose (2.47) and 50 KR showed maximum variance (0.41) and CV (25.31%).

In both the varieties 50 KR dose produced maximum values of GCV (33.57, 22.79) and PCV (35.71, 25.98) and the same dose registered highest heritability (0.883) and GA (65.00) in B-1 while in PDM-84-139 the same parameters were highest in 70 KR (0.778) and 50 KR (41.11) respectively.

It was observed that 70 KR mutagen dose showed significantly maximum branch number per plant, as compared to all other doses and was indifferent of genotypes and no significant mean effect was found due to different genotypes.

In the present investigation number of branches in B-1 was increased due to the effect of gamma ray irradiation. And similar observation was also reported by Seth and Choudhury (1989) and in case of PDM-84-139, number of branches per plant were reduced with increase in doses of gamma rays and it has been previously reported by Ganguli and Bhaduri (1980) in greengram.
4.2.4 Number of pods per plant:

In B-1 all the treatments showed positive shift in mean values (Table 7) as compared to control. Maximum shift for this trait was observed (66.20) at 70 KR and the shift was maximum (58.73) at 50 KR and it also showed maximum variance (379.50) and CV (33.17%).

In PDM-84-139, the increase in pod number per plant was observed up to 70 KR dose and it was maximum (53.53) along with high range (42.00 – 66.00) and variance (50.40) and CV (15.30%) were observed at 30 KR for the same trait.

50 KR gamma rays exhibited maximum GCV (34.26), PCV (34.71) along with genetic advance as percentage of mean (69.66) in case of B-1 while PDM-84-139 showed maximum GCV (15.84), PCV (16.07) and GA (32.16) at 30 KR dose. But in both the varieties, 70 KR dose caused maximum heritability (0.982, 0.987).

B-1 showed better performance for this particular trait in all other doses i.e. 30 KR, 50 KR and 70 KR but the performance of PDM-84-139 was superior to control population in this regard in respect of this character.

The result from the analysis of variance in M1 it was found that higher number of pods per plant was obtained from the 70 KR dose of gamma rays treatment and was significant, as compared to other doses indifferent of genotypes. B-1 always recorded higher number of pods per plant as compared to PDM-84-139.

These observations are in conformity with the earlier report of Dahiya (1973) where he irradiated two varieties of greengram by 30 and 70 KR doses of gamma rays and observed increased number of pods per plant with increase of doses.

4.2.5 Pod length (cm):

From the mean value (Table 8) it was clear about the positive shift, except 30 KR dose where it showed negative shift (6.47) in B-1 while in case of PDM-84-139 there was positive shift up to 50 KR only.
Table 6: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for branch number per plant in M₁ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0</td>
<td>2.27</td>
<td>1.00-4.00</td>
<td>1.35</td>
<td>51.18</td>
<td>54.03</td>
<td>55.22</td>
<td>0.957</td>
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<td>30</td>
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<td>2.00-4.00</td>
<td>0.55</td>
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<td>0.833</td>
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<td>35.71</td>
<td>0.883</td>
<td>65.00</td>
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<td>70</td>
<td>3.07</td>
<td>2.00-5.00</td>
<td>0.50</td>
<td>23.03</td>
<td>17.36</td>
<td>23.06</td>
<td>0.567</td>
<td>27.03</td>
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<tr>
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<td>2.13</td>
<td>1.00-3.00</td>
<td>0.41</td>
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<td>2.00-4.00</td>
<td>0.41</td>
<td>25.31</td>
<td>22.79</td>
<td>25.98</td>
<td>0.769</td>
<td>41.11</td>
</tr>
<tr>
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<td>70</td>
<td>2.47</td>
<td>2.00-3.00</td>
<td>0.27</td>
<td>21.04</td>
<td>19.58</td>
<td>22.20</td>
<td>0.778</td>
<td>35.63</td>
</tr>
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</table>

|          |              | 2.65 | 1.00-5.00   | 0.88 | 35.40|      |      |       |                 |
| B-1      |              | 2.47 | 1.00-4.00   | 0.39 | 25.28|      |      |       |                 |
| PDM-84-139 |              | 2.47 | 1.00-4.00   | 0.39 | 25.28|      |      |       |                 |
|           | 0            | 2.20 | 1.00-4.00   | 0.39 | 25.28|      |      |       |                 |
|           | 30           | 2.60 | 2.00-4.00   | 0.46 | 26.09|      |      |       |                 |
|           | 50           | 2.67 | 2.00-5.00   | 0.64 | 29.96|      |      |       |                 |
|           | 70           | 2.77 | 2.00-5.00   | 0.46 | 24.48|      |      |       |                 |
| Overall  |              | 2.56 | 1.00-5.00   | 0.64 | 31.25| 6.73 | 7.62 | 0.780 | 12.10          |

<table>
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<th>Source</th>
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<td>Dose</td>
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<tr>
<td>Interaction</td>
<td>0.18</td>
<td>NS</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan’s test
Table 7: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for number of pods per plant in $M_1$ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
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<td>34.00-52.00</td>
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<td>15.95</td>
<td>16.09</td>
<td>0.982</td>
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<td>30.00-85.00</td>
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<td>NS</td>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 8: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for pod length (cm) in $M_1$ of greengram

<table>
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<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
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<td>13.87*</td>
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<td>4.50-8.00</td>
<td>0.50</td>
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<tr>
<td>Overall</td>
<td>-</td>
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<td>11.27</td>
<td>2.48</td>
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<tr>
<td>Dose</td>
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<td>NS</td>
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<tr>
<td>Interaction</td>
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<td>NS</td>
</tr>
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In B-1, GCV, heritability and GA were found maximum at 50 KR dose (13.55, 0.858, 25.94) whereas 30 KR produced maximum PCV (15.14). In case of PDM-84-139, higher amount of GCV (13.87), PCV (14.36) as well as GA (27.61) were observed at 30 KR dose but 70 KR dose registered maximum heritability (0.943).

4.2.6 Number of seeds per pod:

In both the varieties 50 KR was found to produce maximum number of seeds/pod (10.93 and 10.33) and they also showed maximum range (6.00 – 14.00, 3.00 – 13.00) as well as CV (18.55, 25.54) at 30 KR. The maximum GCV (18.38), PCV (19.22) and GA (36.18) were noted at 70 KR and heritability (0.958) at 50 KR dose in B-1 while in case of PDM-84-139, 30 KR produced maximum GCV (23.96), PCV (26.24) and GA (45.08) but for heritability it was maximum (0.909) at 70 KR. (Table 9).

4.2.7 100 seed weight (g):

In both the varieties the maximum increase in 100 seed weight (2.79 g, 3.54g) were noted at 70 KR. Maximum range (2.20-3.30) as well as CV(11.39%) in B-1 were exhibited at 50 KR, but in case of PDM-84-139 the range was found maximum (3.20-3.70) when treated with 50 KR and maximum CV(7.42%) were recorded at 30 KR dose of gamma rays (Table 10).

In B-1, 50 KR registered maximum GCV (11.70) and GA (23.16) whereas 70 and 30 KR dose respectively produced maximum PCV (12.26) and heritability (0.943). But for PDM-84-139, GCV(7.60), PCV(8.07) and GA (18.85) were maximum at 30 KR dose and on the other hand 50 KR dose produced maximum heritability (0.922) for this trait.

Singh et al. (2001) have also reported similar trend of increase in 100 seed weight due to mutation.

4.2.8 Seed yield per plant:

In B-1 considerable increase in seed yield per plant over control was observed at most of the treatments (Table 11). Highest mean values (12.15g) along with high CV (16.89%), GCV (17.02), PCV (17.67) and GA (33.74) were observed at 50 KR. While, 70 KR recorded maximum heritability (0.964) in case of B-1.
Table 9: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for seeds per pod in $M_1$ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
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Table 10: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for 100 seed weight (g) in $M_1$ of greengram

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Table 11: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for seed yield per plant (g) in $M_1$ of greengram

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<th>PCV</th>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
Table 12: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for harvest index in $M_1$ of greengram

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<td>Interaction</td>
<td>1.23</td>
<td>3.72</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Positive shift (10.59g) was found at 70 KR in PDM-84-139 but at 30 KR dose it showed negative shift (10.04g). The range (9.80-12.30), CV (6.40%), GCV (6.33), PCV(6.73) and GA (12.28) were maximally observed at 70 KR. Whereas 50 KR exhibited maximum heritability (0.953).

In M1 the result due to analysis of variance revealed the higher amount of seed yield at 70 KR of gamma rays as compared to other doses indifferent of genotypes. Moreover, due to varying genotypes no significant mean effect was observed. Significant interaction between genotype and dose was observed for the same.

4.2.9 Harvest index: 

In case of B-1, there was a positive shift in the mean over control (Table 12) and the maximum increase (40.33) for this trait was observed at 50 KR whereas a negative shift (28.12) was registered at 30 KR. Maximum values of CV(19.86%), GCV (19.54), PCV(20.50) as well as genetic advance (39.97) were recorded at 30 KR of gamma rays while maximum heritability (0.974) was observed at 50 KR.

In case of PDM-84-139, the maximum increase (38.23) in harvest index was observed at 70 KR dose and decrease in mean values were recorded at 30 KR of gamma rays. 70 KR exhibited highest CV (19.64%), GCV(19.99), PCV(20.56) and GA as percentage of mean (40.05) but for heritability it was found maximum at 30 KR (0.987).

In the M1 from the result of analysis of variance it was clear that 50 KR exhibited higher amount of harvest index significantly as compared to other doses, indifferent of genotypes and there was no significant mean effect due to varying genotypes. Significant interaction was also found between genotype and dose.
4.3 M₂ generation:

Table 13: Frequency and spectrum of chlorophyll mutations in M₂ generation of PDM-84-139 and B-1

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total plants studied</th>
<th>Percent chlorophyll mutation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Albina</td>
<td>Xantha</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
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<td>0.08</td>
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</tr>
<tr>
<td>30 KR</td>
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<td>0.12</td>
<td>0.01</td>
</tr>
<tr>
<td>50 KR</td>
<td></td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>70 KR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-1</td>
<td>Control</td>
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<td></td>
</tr>
<tr>
<td>30 KR</td>
<td></td>
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<td>-</td>
</tr>
<tr>
<td>50 KR</td>
<td></td>
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<td>0.04</td>
</tr>
<tr>
<td>70 KR</td>
<td></td>
<td>0.18</td>
<td>0.06</td>
</tr>
</tbody>
</table>

4.3.1 Chlorophyll mutations in mungbean

The chlorophyll mutation frequency was calculated dose wise per 100 M₂ plants. The chlorophyll mutation was classified at the time of seedling stage. In both the varieties, chlorophyll mutants were induced in M₂ generation at fair frequency (Table 13). However, four types of chlorophyll mutation (Bahl & Gupta, 1982) namely albina (white, lethal), xantha (yellow to yellowish white, lethal), chlorina (yellowish green, lethal) and maculata (yellow green spots on the leaves, viable) were observed. The frequency of different types of chlorophyll mutations revealed that the occurrence of albina mutant was maximum followed by chlorina, xantha and maculata in the variety PDM-84-139. On the other hand the frequency of chlorina mutant was maximum followed by albina and maculata.
Table – 14: Spectrum and frequency of macro mutations in B-1 and PDM-84-139 in M₂ generation

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tall</th>
<th>Dwarf</th>
<th>Bushy</th>
<th>Erect</th>
<th>Compact</th>
<th>Synchronous maturity</th>
<th>Spreading / creeping</th>
<th>Early maturing</th>
<th>Late maturing</th>
<th>Male sterile</th>
<th>Long pod</th>
<th>Bold seed</th>
<th>High yielding</th>
<th>Total</th>
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<tbody>
<tr>
<td>B-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>10</td>
<td>4</td>
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<td>30</td>
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<tr>
<td>PDM-84-139</td>
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<tr>
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<td>1</td>
<td>1</td>
<td>-</td>
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<tr>
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<td>-</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>26</td>
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</tbody>
</table>
It is evident (Table 4) from the data that the higher doses of mutagens were more effective in inducing greater frequencies of chlorophyll mutations in both the cultivars in accordance with the finding reported by Santosh (1965). The occurrence of chlorophyll mutation after mutagenic treatments were reported in mungbean by Kulkarni (1986) Singh and Yadav (1991b), Singh et al. (2000) etc.

4.3.2 Macro mutation in mungbean

Mutation frequency was highest in 70 KR dose of gamma ray treatment in both the varieties (Table 14). The mutagen showed independent response of the doses as they occur at random. The two varieties differed at mutagenic specificity that was revealed from the spectrum of mutation. Among all the treatment of gamma ray doses, the mutation spectrum in B-1 was much wider (9 types) at 50 KR gamma rays followed by 70 KR and 30 KR doses respectively whereas PDM-84-139 registered 8 types of mutation induced at 30 KR and 70 KR dose followed by 50 KR.

Several types of macro mutation such as dwarf, tall, bushy, creeping/spreading, synchronous maturity type, partly sterile and high yielding type were observed in the M₂ generation.

The genetic differences in cultivars under reference for inducing spectrum and macromutation frequency were observed in mungbean by Kulkarni (1986), Singh and Yadav (1991b). Singh et al. (1999) reported mutations for plant type, branching pattern, leaf morphology, peduncle length, pod length, seed colour and boldness etc. in mungbean and urdbbeans by radiation and chemical mutagens employed alone or in combination.

4.4 Induced variability for polygenic traits in M₂ generation:

The variability for polygenic traits can be enhanced on positive as well as negative side through induced mutagenesis. Study of the direction of shift in mean values and extent of variability for quantitative trait is important in ascertaining whether mutation breeding can be useful in improvement of the trait of interest. The effect of three doses (30, 50 and 70 KR) of gamma rays treatment on two varieties of greengram and subsequent change on the following attributing characters have been studied in the present investigation.
4.4.1 Biological yield (g):

In case of biological yield both the varieties showed a change in positive as well as in negative directions over control (Table 15). In B-1, the maximum increase of this trait was observed when treated with 30 KR dose (34.72 g) as compared to control (30.43) and the same dose produced maximum range (26.20-52.80). High CV (18.51%), GCV (16.46), PCV (18.72) and genetic advance as percentage of mean (29.82) were noticed at 70 KR gamma rays whereas high heritability (0.887) was recorded at 30 KR.

In case of PDM-84-139, maximum mean (39.53 g) was noticed at 30 KR gamma rays along with high range (32.80-45.80) and heritability (0.815). 70 KR was noted to produce maximum CV(13.07%), GCV (9.94), PCV(13.16) and genetic advance as percentage of mean(15.33).

Analysis of variance results due to M2 data showed that 30 KR gamma rays registered significantly higher amount of biological yield than all other doses irrespective of genotypes and no significant mean effect was found due to varying genotypes. Genotype PDM-84-139 exhibited maximum biological yield as compared to B-1. It showed non significant interaction between genotype and dose.

4.4.2 Plant height (cm):

In both the varieties plant height shifted in the negative direction as compared to control and in both the cases 30 KR produced maximum mean values in B-1 (42.83 cm) and PDM-84-139 (38.14 cm). Maximum range (33.40 - 54.20), CV (13.09%) GCV (12.75) PCV (13.36), heritability (0.912) and genetic advance (25.10) were noticed at 30 KR doses in B-1. In PDM-84-139, the range was maximum (32.60-43.60) at 30 KR dose of gamma rays. The maximum of CV (8.74%), GCV (7.87), PCV (8.90), heritability (0.782) and genetic advance as percentage of mean (14.34) were recorded at 70 KR (Table 16).

In M2, significantly higher plant height was observed at 0- KR (control) than the other doses and the variety B-1 showed higher plant height as compared to the variety PDM-84-139. There was significant interaction between genotype and dose in this regard.
It was interesting to note that none of the plants in both the varieties was taller than their respective controls and the decrease in plant height might have been obviously caused due to increase in frequency of dwarf mutants. Some dwarf plants were isolated and dwarf habit mutants were also observed. It may be mentioned here that indeterminate vegetative growth in pulses as a whole is undesirable character. Because of this indeterminate vegetative growth at the cost of photosynthates, the ultimate economic yield suffer largely. In pulses only 13-15% of the total photosynthates transformed to seed whereas in cereals the corresponding value is about 33-35%. Though protein contains in pulses is three times more than cereals, hence reduction in plant height in mutants over their parent is mostly desirable and it is one of the objectives of the present research programme.

Pande and Raghuvanshi (1988) and Tickoo (1987) reported mutants of dwarf habit in advanced generations of gamma ray and chemical mutagen treated population in mungbean.

4.4.3 Branch number per plant:

With regard to mean number of branches in B-1 there was increase in treatments as compared to control (Table 17) that means there was a positive shift in the mean over the control and the maximum increase (2.95) for this character was recorded at 50 KR while in the case of PDM-84-139 a shift towards reduced branch number per plant was maximum at 70 KR (2.55) as compared to the value of control (2.62) and it was found to maximum (2.69) at 50 KR dose. In both the varieties CV was found maximum (20.88% and 17.82%) at 70 KR gamma rays.

Genotype B-1 showed maximum GCV (17.54), heritability (0.798) as well as genetic advance (32.20) among the plant population treated with 50 KR dose while 70 KR exhibited high PCV (20.73)

In PDM-84-139, 70 KR dose recorded maximum GCV(15.26), PCV (18.18), heritability(0.705) and genetic advance as percentage of mean(26.27).

50 KR registered significantly higher branch number per plant as compared to all other doses in M2 and besides it significant mean effect for this character was observed in
Table 15: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for biological yield (g) in M$_2$ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0</td>
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<td>26.80 - 34.20</td>
<td>2.54</td>
<td>1.59</td>
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<td>3.19</td>
<td>5.06</td>
<td>0.397</td>
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</tr>
<tr>
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<td>30</td>
<td>34.72</td>
<td>26.20 - 52.80</td>
<td>29.61</td>
<td>5.44</td>
<td>15.67</td>
<td>15.10</td>
<td>16.03</td>
<td>0.887</td>
<td>29.29</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>32.38</td>
<td>24.30 - 41.60</td>
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<td>3.43</td>
<td>10.59</td>
<td>9.63</td>
<td>10.84</td>
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<td>70</td>
<td>29.28</td>
<td>20.00 - 37.30</td>
<td>29.36</td>
<td>5.42</td>
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<td>16.46</td>
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<td>6.76</td>
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<td>19.76</td>
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<td>9.94</td>
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<td>0.573</td>
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</tr>
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<td>20.00 - 52.80</td>
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<td>4.72</td>
<td>14.90</td>
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<tr>
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<td>36.57$^p$</td>
<td>20.80 - 48.40</td>
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<td>5.01</td>
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<tr>
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<td>32.90$^c$</td>
<td>20.80 - 48.40</td>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan’s test.
Table 16: Mean, range, variance, GCV, PCV, h² and expected Genetic Advance for plant height (cm) in M₂ of greengram

<table>
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<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
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<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>h²</th>
<th>GA as % of mean</th>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
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</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
case of B-1 as compared to PDM-84-139. Significant interaction has also been noticed between genotype and dose.

4.4.4 Number of pods per plant:

In B-1 the mean values of number of pods per plant showed (Table 18) an increase in most of the treatments and the maximum increase (52.80) was recorded in the plant population derived from the treatment of 70 KR dose and it also recorded high range (28.60-79.00). On the other hand, in case of PDM-84-139, 50 KR exhibited the maximum mean (53.36) as well as range (42.20-72.40). CV (22.31%) was invariably higher in 50 KR of gamma rays in B-1 as compared to the CV (13.73%) of PDM-84-139 at the 50 KR treatment of gamma ray.

In B-1, 70 KR of gamma rays was found to produce maximum GCV (22.55), PCV (22.83), heritability (0.975) and genetic advance (45.87) and in the case of PDM-84-139 high PCV (13.93), heritability (0.959) and genetic advance (27.53) were observed at 50 KR dose of gamma rays whereas maximum GCV (13.73) was exhibited by 30 KR.

In M₉ for this trait, significantly higher number of pods per plant was observed at 50 KR dose, comparing all the doses and the variety B-1 also showed significantly higher number of pods per plant than the variety, PDM-84-139. Significant interaction between genotype and dose were also noticed.

Increased number of pods of greengram in M₉ generation was also observed by Ahmad and Yaqoob (1993) and Singh et al. (2001).

4.4.5 Pod length (cm):

As regards to pod length there was shift in both the direction over control in B-1 and maximum increase in pod length (6.94 cm) was observed at 50 KR dose and maximum decrease (6.54 cm) was recorded at 70 KR of gamma rays. The maximum range (4.10-7.90), CV (10.86%) were observed at 30 KR dose and the GCV (10.47), PCV (11.04), heritability (0.898) and genetic advance as percentage of mean (20.39) were also found maximum at this treatment (Table 19).
Table 18: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for number of pods per plant in M$_2$ of greengram

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<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 19: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for pod length (cm) in M$_2$ of greengram

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Source | SE (m) | CD (0.05) |
-------|--------|-----------|
Genotype | 0.02 | 0.07 |
Dose | 0.03 | 0.09 |
Interaction | 0.04 | 0.13 |

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
In case of PDM-84-139, maximum increase (6.75 cm) against this trait was observed at 50 KR while 70 KR produced negative shift (6.40) as compared to control (6.44) for this trait. The maximum values of range (5.30-7.30), CV (7.31%), GCV (6.58), PCV (7.32), heritability (0.810) as well as genetic advance (12.18) were recorded in the plant population derived from 30 KR dose.

In M₂ 50 KR dose of gamma rays treatment registered significantly higher pod length than all other doses and B-1 also exhibited significant mean effect for this particular trait and between genotype and dose there was a significant interaction.

4.4.6 Number of seeds/pod:

In B-1 positive shift was observed among plant population obtained from almost all the treatments as compared to control (10.98) except at 70 KR dose where it showed negative value (10.85) and in PDM-84-139 positive shift was recorded. In case of B-1 maximum mean (11.81) was observed at 50 KR dose whereas 30 KR exerted highest mean value (11.04) in genotype PDM-84-139. CV among treated population was higher than the control in both the varieties. The genotype B-1 at 30 KR dose exhibited maximum CV (13.21%) as compared to the CV (8.24) of the genotype PDM-84-139 at 30 KR dose of gamma rays (Table 20).

In case of B-1, 30 KR was found to give maximum GCV (11.39), PCV (13.50) as well as genetic advance as percentage of mean (19.73) while, maximum heritability (0.762) exhibited by 70 KR. Similarly in case of PDM-84-139, 30 KR showed high GCV (5.14), PCV (7.91), genetic advance as percentage of mean (6.88) along with moderate heritability (0.423).

For this trait significantly higher seed per pod was observed at 50 KR gamma rays in M₂ as compared to all other treatments. Genotype B-1 showed significantly higher seeds per pod and significant interaction between genotype and dose were also noticed.

It was similar with the findings of Brock (1971) that radiation leads to a reduction in the general mean.
4.4.7 100 seed weight:

In both the varieties M$_2$ mean for plant height shifted in both the directions over control (Table 21), 50 KR exhibited maximum mean in respect of 100 seed weight in both the genotypes (2.91 g, 3.59 g). The maximum range (2.54-3.34) was observed at 50 KR dose in B-1 and PDM-84-139 registered maximum range (2.88-3.98) at 30 KR. Both the genotypes showed high CV (9.23% and 8.04%) at 70 and 30 KR respectively.

Maximum GCV (7.24), PCV (9.28) and GA (11.45) were observed at 70 KR whereas maximum heritability (0.723) showed by 50 KR in B-1. In PDM-84-139, 30 KR produced high GCV (7.33), PCV (8.21), heritability (0.796) as well as genetic advance as percentage of mean (13.47).

Analysis of variance revealed that 50 KR exhibited higher 100 seed weight significantly than other doses and the genotype PDM-84-139, showed higher 100 seed weight as compared to B-1.

From the available result it can be concluded that higher dose had the efficiency to effectively induce variation in the population and selection towards improvement for this important trait can be practiced among the families raised from the higher doses.

4.4.8 Seed yield per plant:

In case of seed yield per plant the mean was shifted in both the directions as compared to control. Maximum mean was observed at 50 KR in both the varieties (10.89 g and 11.02 g). Range (10.00-13.80) and CV (7.36%) was invariably higher in B-1 as compared to the range (10.20-13.20) CV (7.11%) of PDM-84-139 at 50 KR of gamma rays (Table 22).

In B-1, 50 KR was found to produce maximum GCV (7.00), PCV (7.48), heritability (0.874) as well as genetic advance (13.50) while in case of PDM-84-139 maximum values of GCV (7.01), PCV (7.22), heritability (0.943) and genetic advances percentage of mean (13.97) were observed at the same dose.

Seed yield per plant was significantly higher at 50 KR gamma rays as compared to all other treatments in M$_2$ and B-1 also registered significantly higher seed yield per
Table 20: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for seeds per pod in $M_2$ of greengram.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
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<td>10.00 - 12.00</td>
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<td>2.00</td>
<td>4.68</td>
<td>0.582</td>
<td>1.73</td>
</tr>
<tr>
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<td>30</td>
<td>11.20</td>
<td>7.00 - 14.00</td>
<td>2.19</td>
<td>1.48</td>
<td>13.21</td>
<td>11.39</td>
<td>13.50</td>
<td>0.711</td>
<td>19.73</td>
</tr>
<tr>
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<td>11.00 - 13.00</td>
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<td>1.55</td>
<td>5.36</td>
<td>0.684</td>
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<tr>
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<td>10.85</td>
<td>8.00 - 13.00</td>
<td>1.23</td>
<td>1.11</td>
<td>10.23</td>
<td>8.65</td>
<td>9.91</td>
<td>0.762</td>
<td>15.58</td>
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<tr>
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<td>9.00 - 11.00</td>
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<td>0.57</td>
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<td>5.79</td>
<td>0.700</td>
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<td>8.00 - 13.00</td>
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<td>0.91</td>
<td>8.24</td>
<td>5.14</td>
<td>7.91</td>
<td>0.423</td>
<td>6.88</td>
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<td>0.83</td>
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<td>4.50</td>
<td>7.74</td>
<td>0.338</td>
<td>5.39</td>
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<td>4.62</td>
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<td>10.97</td>
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<tr>
<td>-</td>
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<td></td>
<td></td>
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<tr>
<td>-</td>
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<td>10.42b</td>
<td>8.00 - 13.00</td>
<td>0.91</td>
<td>0.95</td>
<td>9.12</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>7.00 - 14.00</td>
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<td>1.04</td>
<td>9.60</td>
<td>4.83</td>
<td>5.34</td>
<td>0.817</td>
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<th>CD (0.05)</th>
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<td>0.21</td>
</tr>
<tr>
<td>Dose</td>
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<td>0.29</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.14</td>
<td>0.41</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
Table 21: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for 100 seed weight (g) in M$_2$ of greengram

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
</tr>
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<tbody>
<tr>
<td>B-1</td>
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<td>2.58 - 2.88</td>
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<td>0.08</td>
<td>2.99</td>
<td>0.76</td>
<td>2.94</td>
<td>0.428</td>
<td>3.71</td>
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<tr>
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<td>30</td>
<td>2.83</td>
<td>2.50 - 3.24</td>
<td>0.03</td>
<td>0.17</td>
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<td>4.41</td>
<td>6.07</td>
<td>0.527</td>
<td>6.71</td>
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<tr>
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<td>50</td>
<td>2.91</td>
<td>2.54 - 3.34</td>
<td>0.03</td>
<td>0.17</td>
<td>5.80</td>
<td>5.01</td>
<td>5.89</td>
<td>0.723</td>
<td>8.93</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>2.62</td>
<td>2.16 - 3.02</td>
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<td>0.24</td>
<td>9.23</td>
<td>7.24</td>
<td>9.28</td>
<td>0.609</td>
<td>11.45</td>
</tr>
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<td>PDM-84-139</td>
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<td>3.08 - 3.78</td>
<td>0.03</td>
<td>0.17</td>
<td>4.88</td>
<td>3.13</td>
<td>4.79</td>
<td>0.428</td>
<td>4.11</td>
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<td>2.88 - 3.98</td>
<td>0.08</td>
<td>0.28</td>
<td>8.04</td>
<td>7.33</td>
<td>8.21</td>
<td>0.796</td>
<td>13.47</td>
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<tr>
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<td>3.59</td>
<td>2.98 - 3.96</td>
<td>0.05</td>
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<td>0.671</td>
<td>8.08</td>
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<tr>
<td></td>
<td>70</td>
<td>3.38</td>
<td>3.00 - 3.90</td>
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<td>0.21</td>
<td>6.29</td>
<td>4.46</td>
<td>6.36</td>
<td>0.492</td>
<td>6.51</td>
</tr>
</tbody>
</table>

| B-1       | -                  | 2.77  | 2.16 - 3.34 | 0.04     | 0.21 | 7.41 |      |      |       |         |
| PDM-84-139| -                  | 3.47  | 2.88 - 3.98 | 0.06     | 0.24 | 6.78 |      |      |       |         |
| -         | 0                  | 3.07$^c$ | 2.58 - 3.78 | 0.13     | 0.36 | 11.85|      |      |       |         |
| -         | 30                 | 3.16$^b$ | 2.50 - 3.98 | 0.16     | 0.40 | 12.75|      |      |       |         |
| -         | 50                 | 3.25$^a$ | 2.54 - 3.96 | 0.16     | 0.39 | 12.13|      |      |       |         |
| -         | 70                 | 3.00$^d$ | 2.16 - 3.90 | 0.20     | 0.45 | 14.89|      |      |       |         |
| Overall   | -                  | 3.12  | 2.16 - 3.98 | 0.17     | 0.41 | 13.21| 3.41 | 3.71 | 0.846 | 6.41            |

<table>
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<tr>
<td>Dose</td>
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</tr>
<tr>
<td>Interaction</td>
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<td>NS</td>
</tr>
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</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 22: Mean, range, variance, GCV, PCV, \( h^2 \) and expected Genetic Advance for seed yield per plant (g) in \( M_2 \) of greengram

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<tr>
<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>( h^2 )</th>
<th>GA as % of mean</th>
</tr>
</thead>
<tbody>
<tr>
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<td>9.20 - 10.70</td>
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<td>0.31</td>
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<td>2.54</td>
<td>3.12</td>
<td>0.660</td>
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</tr>
<tr>
<td></td>
<td>30</td>
<td>10.62</td>
<td>9.80 - 11.80</td>
<td>0.31</td>
<td>0.55</td>
<td>5.21</td>
<td>4.76</td>
<td>5.31</td>
<td>0.807</td>
<td>8.85</td>
</tr>
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<td></td>
<td>50</td>
<td>10.89</td>
<td>10.00 - 13.80</td>
<td>0.64</td>
<td>0.80</td>
<td>7.36</td>
<td>7.00</td>
<td>7.48</td>
<td>0.874</td>
<td>13.50</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>9.90</td>
<td>8.60 - 12.00</td>
<td>0.48</td>
<td>0.69</td>
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<td>0.47</td>
<td>4.38</td>
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<td>Overall</td>
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<td>Interaction</td>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 23: Mean, range, variance, GCV, PCV, $h^2$ and expected Genetic Advance for harvest index in M$_2$ of greengram

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<th>Genotype</th>
<th>Mutagen dose (KR)</th>
<th>Mean</th>
<th>Range</th>
<th>Variance</th>
<th>SD</th>
<th>CV%</th>
<th>GCV</th>
<th>PCV</th>
<th>$h^2$</th>
<th>GA as % of mean</th>
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<td>2.03</td>
<td>6.17</td>
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<td>5.87</td>
<td>0.416</td>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
plant than PDM-84-139. Between genotype and dose there was a significant interaction against this trait. Seed yield per plant is an important character which has contribution towards higher productivity for the improvement of this trait. In case of greengram 50 KR treatment of gamma rays is most effective.

4.4.9 Harvest index:

In case of both the varieties, the mean values of harvest index shifted (Table 23) in positive directions as compared to the control. Maximum increase (35.08) was observed at 70 KR and 30 KR produced maximum decrease (31.28) while, in case of PDM-84-139 the maximum increase (32.92) was also noticed at 70 KR. Gamma rays on minimum in 50 KR.

The values of CV (21.31%) and range (25.40-49.95) obtained in B-1 were maximum at 70 KR gamma rays and maximum values of GCV (18.32), PCV (21.43), and genetic advance (32.27) were recorded at 70 KR whereas high heritability (0.780) was observed at 50 KR gamma rays.

In case of PDM-84-139, CV (14.06%), range (25.69-45.78), GCV (9.33), PCV (13.37) and genetic advance as percentage of mean (16.91) were observed maximum at 70 KR and heritability values (0.808) and genetic advance (15.60) were found maximum at 30 KR.

70 KR gamma rays in M2 produced higher amount of harvest index compared to all other doses of gamma rays. Genotype B-1 showed maximum harvest index as compared to the genotype, PDM-84-139 and a significant interaction was observed to occur between genotype and dose in this regard.

It is generally believed that in any population the induced mutation reduce the mean. Since the desirable genes would be mutating with undesirable ones. The mean performance of a population having equal proportion of favourable and unfavourable genes would remain unchanged as mutation in positive and negative directions would be more or less equal. The present findings were in agreement with the findings of Rajput, where the shifts in mean values of irradiated material at M2 generation of mungbean of all the polygenic traits occurred towards the positive direction except for mean for pod length which remains unchanged.
Dahiya, Grover and Tejpaul reported that gamma radiation were effective in inducing considerable variations for yield and yield attributing characters, namely yield per plant, grain size, number of pods per plant, number of seeds per pod, number of seeds per plant, 1000 grain weight, days to flowering and protein content in greengram.

4.5 M₃ generation:

The performance of different viable mutants which were identified and selected considering different yield attributing parameters in M₃ generation are as follows:

Genotype PDM-84-139:

Normal plant type of genotype PDM-84-139 have been shown in plate No. 1 and the description of other mutant are as follows-

Dwarf mutant: Only one mutant was observed in 30 KR dose (Plate No. 2). They had shorter internodes, smaller leaves and recorded significantly lower yield per plant (9.80 g) than the control (10.53 g). The same dose produced the bushy mutants (Plate No. 3) as well as the synchronous maturing mutants (Plate No. 4).

Tall mutant: Tall mutant plants were isolated only when the parent treated with 30 KR dose of gamma rays (Plate No. 5). These plants grew to a height of 58 to 62 cm while the parent attained maximum height of 56 cm.

Top bearing mutant: Only one mutant (Plate No. 6) was observed in 50 KR dose. The mutant was erect in habit and produced bearing at the top portion.

Early maturing mutant: They were early in maturing and matured in 57-62 days as compared to the normal period of 71 days. From the 50 KR gamma ray treatment these type of mutant were derived (Plate No. 7) as well as bold seeded mutant were also found at the same dose. They produced bold seeds as compared to control

Genotype B-1:

Normal plant of the genotype B-1 have been shown in plate No. 8 and the other mutants that were identified in M₃ generation are as follows-
PLATE 1. NORMAL PLANT
(Var. PDM-84-139)

PLATE 2. DWARF MUTANT PLANT
(Var. PDM-84-139)
PLATE 3. BUSHY MUTANT
(Var. PDM-84-139)

PLATE 4. SYNCHRONOUS MATURING MUTANT
(Var. PDM-84-139)
PLATE 5. TALL MUTANT
(Var. PDM-84-139)

PLATE 6. TOP BEARING MUTANT
(Var. PDM-84-139)
PLATE 7. EARLY MATURING MUTANT
(Var. PDM-84-139)

PLATE 8. NORMAL PLANT
(Var. B1)
**Erect mutant plant:** These types of mutants were isolated at 30 KR gamma ray dose (Plate No. 9) and the same dose produced synchronous maturing mutants which matured more or less at the same time (Plate No. 10).

**Higher pod bearing mutant:** At 50 KR dose of gamma rays two higher pod bearing mutants were observed (Plate No. 11). They were semi tall in growth with significantly higher number of pods and grain yield over the control.

**Bushy mutant:** Three mutants were isolated in 50 KR dose (Plate No. 12). They had shorter internodes and compact structure. They also had higher number of branches and pods as compared to the control population. The compact nature of these mutants may be helpful in growing large number of plants per unit area.

**Tall and late maturing mutant:** Two mutants were isolated at 30 KR gamma ray treatment. Their height ranged from 61-65 cm as compared to control (58.93 cm). These tall plants were conspicuous by their late flowering (10-15 days) as compared to the parental genotype. These mutants possessed semi-trailing habit (Plate No.13). Six dwarf mutants were also found at the same dose. They were most frequent type of mutation and the mutants possessing varying degree of reduction in plant height but they showed determinate growth habit.

**Sterile mutant:** These mutant plants were screened at 50 KR dose. They had a characteristic under developed anthers, which were devoid of pollen grains. In some cases, pollen grains were formed but were sterile in nature (Plate No. 14).

### 4.6 Induced variability for polygenic traits in M₃ generation:

The M₂ families following a selection for yield and yield contributing characters were advanced to M₃ generation for evaluation of the variability parameters and genetic improvement after two generation of selection. The results for the estimate of mean, range and variability parameters character wise were as follows-
PLATE 11. HIGHER POD BEARING MUTANT (Var. B1)

PLATE 12. BUSHY MUTANT (Var. B1)
PLATE 13. TALL AND LATE MATURING MUTANT (Var. B1)

PLATE 14. STERILE MUTANT (Var. B1)
4.6.1 Biological yield (g):

In both the varieties positive shift over parents for this trait was observed (Table 24) and in B-1 it was maximum (37.57 g) in the plant population obtained from 70 KR dose of gamma rays while in case of PDM-84-139, maximum mean value for this trait (47.57 g) was noticed at 50 KR dose. Higher CV(12.08%) produced by genotype PDM-84-139 was considerably more than the CV(9.52%) of other genotype B-1 at the 50 KR dose.

In B-1, the maximum values of GCV (11.64), PCV (11.74), heritability (0.983) as well as genetic advance as percentage of mean (23.75) were recorded at 50 KR dose of gamma rays while in case of PDM-84-139, high GCV (12.77), PCV (13.14), heritability (0.944) and genetic advance (25.56) were also observed at the same dose of gamma rays.

From the analysis of variance in M₃, significant interaction between genotype and dose was noticed.

4.6.2 Plant height (cm):

For this trait negative shift was observed in both the genotypes as compared to parents. Maximum plant height (46.13 cm) was recorded in case of B-1 treated with 50 KR dose while PDM-84-139 showed highest mean (43.15 cm) at 70 KR dose of gamma rays. In B-1, the range (40.20-51.20) and CV (10.45%) were invariably higher for this trait at 50 KR dose, while in case of PDM-84-139, it were maximum (35.20-47.20, 9.13%) at 50 KR dose also (Table 25).

In B-1, 50 KR dose of gamma rays exhibited maximum GCV (13.01), PCV (13.21), heritability (0.970) as well as genetic advance as percentage of mean (57.23).

50 KR gamma ray dose recorded high GCV (9.43), PCV (9.91), heritability (0.906) and GA as percentage of mean (18.49) in PDM-84-139.

For this character interaction between genotype and dose were significant.
4.6.3 Branch number per plant:

In case of branch number per plant, more number of branches per plant were found among all the treatments and they shifted in the positive direction (Table 26) and for B-1, it was maximum (3.50) at 30 KR dose whereas 70 KR showed maximum branches (3.67) in PDM-84-139. In both the varieties, maximum CV were observed (16.41, 12.92) at 30 KR dose of gamma rays.

In B-1, 30 KR was noted to produce maximum GCV (20.07), PCV (20.47), heritability (0.961) and genetic advance (40.57) and in case of PDM-84-139, GCV (13.48), PCV (15.73) as well as genetic advance (23.97) were found maximum at the same dose of gamma rays also but heritability (0.973) at 50 KR. No significant interaction between genotype and dose were noticed for this specific trait.

4.6.4 Number of pods per plant:

Both the genotypes showed maximum number of pods per plant in all treatments as compared to the parent. In B-1 maximum number of pods per plant (88.37) were observed at 50 KR dose treatment and was considerably higher as compared to the pod number (67.76) of the genotype, PDM-84-139 at the same dose effect. The maximum range for both the varieties (84.60-94.80, 59.80-80.20) were also observed at 50 KR dose of gamma rays. CV ranged from 4.60 to 12.92 percent in B-1, whereas 2.68 to 46.36 percent CV were noticed in case of PDM-84-139.

High GCV (16.25), PCV (16.63), heritability (0.956) along with genetic advance as percentage of mean (32.74) were found at 30 KR dose of gamma rays by genotype B-1 and on the other hand for genotype PDM-84-139, 50 KR dose exhibited maximum GCV (10.02), PCV (10.86), heritability (0.852) and GA as percentage of mean (19.05).

The result from the analysis of variance in M2, significantly maximum number of pods per plant (74.63) was observed (Table 27) at 50 KR dose followed by 30 KR (66.53) and 70 KR (60.32) doses of gamma rays indifferent of genotypes. Moreover, significant mean effect was not observed due to varying genotypes but, there was significant interaction between genotype and dose for this trait.
Table 24: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for biological yield (g) in $M_3$ of greengram

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Table 25: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for plant height (cm) in M₃ of greengram.

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Table 26: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, \( h^2 \) and expected Genetic Advance for branch number per plant in M₅ of greengram

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<th>( \sigma^2 ) p</th>
<th>GCV</th>
<th>PCV</th>
<th>( h^2 )</th>
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Table 27: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for number of pods per plant in M₃ of greengram

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<th>$\sigma^2_p$</th>
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<td></td>
<td></td>
<td></td>
<td>0.833</td>
<td>13.80</td>
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</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
4.6.5 **Number of clusters per plant:**

In case of genotype B-1, M₃ mean for cluster number per plant, shifted in positive as well as negative direction of parents (Table 28). Maximum increase (10.50) was observed at 50 KR dose and maximum decrease (9.12) in mean value was recorded at 30 KR dose of gamma rays and similarly genotype PDM-84-139, showed positive shift in mean as compared to control and 70 KR dose of gamma ray produced maximum shift (10.67). The CV of B-1 was also invariably higher (27.10) than the CV (10.20) of PDM-84-139.

GCV (32.83), PCV (34.38), heritability (0.912) and genetic advance as percentage of mean (64.58) registered by B-1 at 30 KR dose of gamma rays were also larger as compared to the GCV (8.90), PCV (10.61) and GA (15.37) by genotype PDM-84-139, at 50 KR dose of gamma rays while, it showed maximum heritability (0.954) at 70 KR dose.

From the analysis of variance result in M₃, significant interaction between genotype and dose were noticed.

4.6.6 **Pod length (cm):**

The mean data (Table 29) indicated that there were positive as well as negative shift in case of B-1. At 70 KR maximum increase (7.07 cm) over parent was observed and the decrease was maximum (6.41 cm) when treated with 50 KR dose of gamma rays. While in case of PDM-84-139 there was a gradual positive shift among the treatments as compared to parent and 50 KR gamma ray dose exhibited maximum (7.41 cm) pod length. The CV (9.36%) registered by 50 KR doses in B-1, was also higher as compared the CV (2.77%) of PDM-84-139.

50 KR in B-1 caused maximum GCV (9.03), PCV (10.56), genetic advance as percentage of mean (15.91) but heritability values was maximum (0.927) at 30 KR dose.

Similarly, in case of PDM-84-139, maximum values of GCV (2.71), PCV (3.54), and genetic advance were noticed at 30 KR dose whereas maximum heritability (0.667) was exhibited by 50 KR dose of gamma rays.
From the analysis of variance result in M₃ a significant interaction was observed between the genotype and dose for this type of trait.

4.6.7 Number of seeds per pod:

The mean was found to increase in all the treatments in both the varieties. In case of B-1 maximum mean for this trait was observed at 50 KR dose while 70 KR dose exhibited highest mean (11.40) for PDM-84-139. Maximum CV was observed in both the varieties at 70 KR dose of gamma rays (5.07, 6.56).

High GCV (5.53), PCV (6.36) along with genetic advance as percentage of mean (9.89) were noted for genotype B-1 at 70 KR dose while maximum heritability (0.835) was exhibited by 50 KR dose of gamma rays. (Table 30).

In PDM-84-139, maximum values of GCV (7.34), PCV (7.65), heritability (0.921) as well as genetic advance (14.47) were observed at 70 KR doses of gamma rays.

For this type of trait no significant interaction between genotype and dose were found.

4.6.8 100 seed weight (g):

From the mean data, there was a considerable increase in 100 seed weight over the parents for all the treatments in both the varieties. A shift towards increased 100 seed weight for the two genotypes were maximum (3.53 g, 3.77 g) at 70 KR dose of gamma rays which also produced higher range (2.92-3.96, 3.42-4.02). CV for this trait, that were found at 70 KR, was invariably higher (12.98%) in B-1 than the CV (6.03%) of PDM-84-139 that were noticed at 70 KR dose of gamma rays (Table 31).

In B-1, 70 KR dose of gamma rays was observed to record maximum GCV (14.61), PCV (15.59) as well as genetic advance as percentage of mean (28.32) while it recorded maximum heritability (0.925) at 30 KR dose and in case of PDM-84-139, 30 KR treatment of gamma rays was found to have maximum GCV (5.38), PCV (7.31) and GA (8.09) while high heritability (0.602) was registered by 50 KR dose.

It was observed that 70 KR mutagen dose of gamma rays, exhibited significantly higher 100 seed weight as compared to all other doses and was indifferent of genotypes
and no significant mean effect was found for varying genotypes. Similarly, no significant interaction was observed.

### 4.6.9 Seed yield per plant (g):

In both the varieties there was a positive shift in the mean over the control for this type of trait (Table 32). Maximum shift for both the varieties were observed at 50 KR dose of gamma rays and the mean value of B-1 was minimum (12.98) as compared to the value of PDM-84-139 (13.89) and the range were also maximum in case of both the varieties at the same doses of gamma rays. CV was invariably higher (8.70%) in case of PDM-84-139, produced by 50 KR dose than the CV of B-1(5.10%) at the 30 KR dose.

GCV (6.42), PCV (6.58) as well as genetic advance as percentage of mean (12.95) were also found higher in B-1 at 30 KR dose while 50 KR dose exhibited maximum heritability values (0.963) similarly, in case of PDM-84-139, 50 KR dose showed maximum GCV (7.03), PCV (8.49) and GA (12.02) but heritability values (0.810) was noticed higher at 70 KR treatment dose.

Analysis of variance results due to M₃ data showed that 50 KR dose of gamma rays had significantly higher amount of seed yield than all other doses of treatment irrespective of genotypes. Significant mean effect was observed due to varying genotypes and simultaneously between genotype and dose there was a significant interaction.

In M₃ generation a shift in mean values were found in the desired direction.

### 4.6.10 Harvest Index:

Positive as well as negative shift were observed for harvest index for both the varieties (Table 33). In B-1, increase mean values was found (36.02) at 50 KR dose while 30 KR dose of gamma ray registered decrease mean value (31.05) as compared to the control. Same phenomenon was observed in PDM-84-139 where maximum (29.43) and minimum values (26.33) were noticed at 50 KR and 30 KR doses of gamma rays respectively. 70 KR dose was noted to produce maximum CV (10.43%) in B-1 as compared to the CV value (9.69%) of PDM-84-139 at 50 KR dose.
Table 28: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for number of clusters per plant in $M_3$ of greengram

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Table 29: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for pod length (cm) in M$_5$ of greengram

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<th>CV%</th>
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<th>$\sigma^2_p$</th>
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Table 30: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for seeds per pod in M$_3$ of greengram

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Table 31: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for 100 seed weight (g) in M₃ of greengram

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<th>$\sigma^2 p$</th>
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<th>PCV</th>
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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
Table 32: Mean, range, variance, phenotypic and genotypic coefficient of variance, GCV, PCV, $h^2$ and expected Genetic Advance for seed yield per plant (g) in M$_3$ of greengram

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* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test
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</table>

* Similar alphabets denote homogeneous main effect means of genotype and mutagen dose at 5% level of significance due to Duncan's test.
In B-1 maximum values of GCV (12.77), PCV (13.28) and genetic advance (25.29) were recorded at 70 KR dose of gamma rays whereas higher heritability values (0.944) was observed at 50 KR dose. 50 KR dose exhibited moderate GCV (7.58) and PCV (9.86) in PDM-84-139 while high heritability (0.895) as well as genetic advance as percentage of mean (12.61) were observed at 70 KR dose.

50 KR registered significantly maximum harvest index as compared to all the remaining doses indifferent of genotypes but no significant mean effect was found between the genotypes. Moreover, a significant interaction between genotype and dose were found. The trends of variability observed in M₃ have created possibility for improved selection in M₃ generations.

4.7 Selection gain:

Selection gain in percent over control population was estimated statistically for all the characters of greengram studied in M₃ generation.

The result in Table 34 revealed that out of the 6 selection at 30, 50 and 70 KR doses of gamma rays only 4 selections recorded greater than 10% selection response by all the doses of gamma rays in B-1 for biological yield. The highest selection response was recorded by S5 (25.83%) at 70 KR followed by S3 (16.53%) in 50 KR and S2 & S1 (15.08%, 13.43%) at 30 KR dose of gamma rays.

Similarly, in case of genotype PDM-84-139, S6 (49.54%) and S5 (44.53%) at 50 KR dose of gamma rays and S8 (37.85%) at 70 KR dose yielded maximum selection response.

For plant height, none of the treated population in both the varieties recorded desirable selection response except S5 (4.30%) in PDM-84-139.

The maximum selection response in B-1 for branches per plant was observed by S2 (46.34%) followed by S3 (39.03%) and S6 (26.83%) whereas, S2 in PDM-84-139 showed maximum value (36.37%) in this regard.
Table 34: Genetic improvement after two generation of selection in greengram

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<th>Variety</th>
<th>Treatment/ dose</th>
<th>Selection No.</th>
<th>Biological yield</th>
<th>Plant height</th>
<th>Branches per plant</th>
<th>Number of pods per plant</th>
<th>Cluster number per plant</th>
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<td>Mean</td>
<td>Selection gain (%)</td>
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SE(m)  0.84  0.78  0.15  1.51  0.31
CD(0.05)  2.42  2.26  0.44  4.35  0.89

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<th>Seeds per pod Mean</th>
<th>Selection gain (%)</th>
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Table 35: Means of different characters under study at the M₃ generation along with parental generation and Duncan’s test results

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<th>Genotype</th>
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<th>Plant height</th>
<th>Branch No. per plant</th>
<th>Pod No. per plant</th>
<th>Cluster No. per plant</th>
<th>Pod length</th>
<th>Seeds per pod</th>
<th>100 seed weight</th>
<th>Seed yield per plant</th>
<th>H.I.</th>
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<td>9.12ᵃᵇ</td>
<td>7.00ᵇ*</td>
<td>11.27ᵃ</td>
<td>3.01ᶜ</td>
<td>11.43ᵈ</td>
<td>31.05ᵇᶜ</td>
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<td>88.37ᵃ</td>
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<td>6.41ᶜ</td>
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<td>12.91ᵇ</td>
<td>36.02ᵃ</td>
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<td>7.07ᵃᵇᶜ</td>
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<td>12.13ᶜ</td>
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<td>PDM-84-139 (30 KR)</td>
<td>44.63ᵃ</td>
<td>42.20ᶜ</td>
<td>3.63ᵃ³</td>
<td>62.27ᶜᵈ</td>
<td>10.51ᵃᵇ</td>
<td>7.21ᵃᵇᶜ</td>
<td>10.97ᵃ</td>
<td>3.71ᵃ</td>
<td>11.75ᶜᵈ</td>
<td>26.33ᵈ</td>
</tr>
<tr>
<td>PDM-84-139 (50 KR)</td>
<td>47.57ᵃ</td>
<td>40.88ᶜ</td>
<td>3.50ᵃᵇ</td>
<td>67.76ᵇᶜ</td>
<td>10.28ᵃᵇ</td>
<td>7.41ᵃ</td>
<td>11.32ᵃ</td>
<td>3.57ᵇᶜ</td>
<td>13.89ᵃ</td>
<td>29.43ᵇᶜ</td>
</tr>
<tr>
<td>PDM-84-139 (70 KR)</td>
<td>47.10ᵃ</td>
<td>43.15ᵇᶜ</td>
<td>3.67ᵃ</td>
<td>58.30ᵈ</td>
<td>10.67ᵃ</td>
<td>7.36ᵃᵇ</td>
<td>11.40ᵃ</td>
<td>3.77ᵃ</td>
<td>13.55ᵃ</td>
<td>29.42ᵇᶜ</td>
</tr>
<tr>
<td>B-1 (Parent)</td>
<td>32.27ᶜ</td>
<td>58.93ᵃ</td>
<td>2.73ᶜ</td>
<td>47.93ᵉ</td>
<td>9.73ᵃᵇ</td>
<td>6.93ᶜ</td>
<td>11.07ᵃ</td>
<td>2.85ᶜ</td>
<td>10.05ᵉ</td>
<td>31.21ᵇᶜ</td>
</tr>
<tr>
<td>PDM-84-139 (Parent)</td>
<td>35.93ᵇ</td>
<td>44.17ᵇᶜ</td>
<td>2.93ᵇᶜ</td>
<td>44.07ᵉ</td>
<td>8.93ᵇ</td>
<td>6.97ᵇᶜ</td>
<td>10.13ᵇ</td>
<td>3.35ᵇ</td>
<td>10.53ᵉ</td>
<td>29.34ᵉ</td>
</tr>
</tbody>
</table>

* Similar alphabets denote homogeneous means due to Duncan's test
Selections were highly effective to produce large amount of response against pod number/plant\textsuperscript{-1}. Response to selection varied between 23.92\% to 89.29\% in B-1 and 27.38\% to 75.64\% in PDM-84-139. 50 KR was the best in this regard.

In B-1, cluster number per plant, pod length as well as seeds per pod were found to produce maximum selection response by S2 (15.75\%), S5 (7.14\%) and S5 (16.45\%) respectively. Whereas in PDM-84-139, S5 showed maximum response for cluster number per plant (26.87\%) as well as seeds per pod (16.45\%) but pod length was maximum in S6 (7.59\%).

The selection response for 100 seed weight in B-1 was found highest in S5 (32.71\%) followed by S8 (16.50\%) in PDM-84-139.

In B-1, S4 exhibited maximum selection response (28.78\%) followed by S3 (27.95\%) and similarly, S5 and S6 of the genotype PDM-84-139 showed maximum response (45.22\% & 32.55\%) respectively. Harvest index registered highest response to selection by S4 (21.03\%) in B-1 and none of the selection in PDM-84-139 showed desirable selection response.

The selections recorded desirable gain under selection for a particular trait can be advanced for further evaluation in M\textsubscript{4} generation. The result indicated that these induced micro mutations using gamma rays may be helpful to isolate improved strain through proper selection as indicated by Gregory (1965).

4.8 **Comparison of mean of the two genotypes with the parental generation following Duncan’s test:**

Simple RBD technique of ANOVA was used followed by Duncan’s test at 5\% level of significance to compare the means of genotype dose combination at M\textsubscript{3} over parental means (Table 35). It was revealed from the table that PDM-84-139 at 50 KR dose of gamma rays produced maximum biological yield, pod length, seed yield per plant. But pod numbers, seeds per pod as well as higher harvest index were noticed at 50 KR dose also by genotype B-1. Similarly, branch number per plant, cluster number per plant as well as 100 seed weight were observed maximum in PDM-84-139 at 70 KR.
Mutation breeding made a significant contribution in the improvement of agrihorticultural crops. The number of mutant varieties officially released and recorded in the FAO/IAEA Mutant Varieties Database (MVD) before the end of the years 2000 is 2252 (Maluszynski et al. 2000). Most of the released varieties of crop plants belong to seed propagated species. About 75% varieties developed and released using induced mutations are of crop plants and 25% are of the ornamentals. A good number of legumes (311 Var.) including mungbean (19 Var.) have been developed through induced mutation. Most of the mutant varieties (around 89%) have been developed using physical mutagens (X-ray, gamma rays, thermal and fast neutrons) with gamma rays alone accounting for the development of 60% of the total mutant varieties. Thus induction of mutation using gamma rays is the most effective method of crop improvement (Kharkwal et al. 2004). A wide range of characters which have been improved through mutation breeding include plant architecture, yield and maturity duration, quality and tolerance to biotic and abiotic stresses. In the present studies a positive improvement of different yield contributing traits through gamma rays treatment has been achieved. The interaction between dose of treatment and varieties have indicated that for greengram 50 KR dose is most effective to achieve optimum results. Further careful selection in advanced generations from well planned experiments a few improved lines with desirable characters over their parents as per objectives of the present programme may be identified which will contribute an important role in the improvement of greengram in respect of yield.
Chapter 5

SUMMARY AND CONCLUSION
SUMMARY AND CONCLUSION

Dry seeds 100 number of each of the two cultivated varieties of greengram namely B-1 and PDM-84-139 developed and released by the Pulse And Oilseed Research Station (PORS), Berhampore, West Bengal and Indian Institute of Pulse Research (IIPR), Kanpur respectively, were irradiated with 3 doses of gamma rays i.e. 30, 50 and 70 KR from the Central Research Institute for Jute and Allied Fibre (ICAR), Barrackpore, West Bengal. The irradiated seeds of both the varieties along with the control (parent) were sown in Randomized Block Design (RBD) with three replications. A spacing of $10 \times 30$ cm was maintained from plant to plant and row to row. Recommended doses of fertilizers (N:P:K:: 20:40:20 kg/ha) along with bio-fertilizer were also applied to provide optimum environment to the genotypes during the entire course of the experiment. Crops were grown in two seasons in kharif and summer during 2002-2005 in the Central Research Farm of Regional Research Station (New Alluvial Zone), Gayeshpur, Nadia, Bidhan Chandra Krishi Viswavidyalaya. Observations on mortality rate in $M_1$ and chlorophyll mutation and yield attributing characters like biological yield (g), plant height (cm), branch number per plant, number of pods per plant, cluster number per plant, pod length (cm), 100 seed weight (g), seed yield per plant (g) and harvest index were recorded from control as well as from the treated population that were grown under identical condition. The varieties of greengram were mainly treated with different doses gamma rays for creating and studying genetic variability in $M_1$, $M_2$ and $M_3$ generations in respect of yield and yield attributing traits and development and selection of superior genotype(s). The main findings as well as outcome of the present research works are as follows:

$M_1$ generation:

With increasing doses of gamma rays treatment a progressive reduction in germination and survival was observed for both the varieties. It was more pronounced in B-1 than PDM-84-139. Comparatively higher frequency of treated seeds germinated later than the controls in both the varieties.
The mean values of different characters like branch number per plant, number of pods per plant, 100 seed weight, increased with increase of doses in comparison to the control. On the other hand the character plant height decreased with increase of doses.

**M₂ generation:**

In the M₂ generation four types of chlorophyll mutation (Table 3) namely albina (white, lethal), xantha (yellow to yellowish white, lethal), chlorina (yellowish green, lethal) and maculata (yellow green spots on the leaves, viable) were observed. The frequency of different types of chlorophyll mutations revealed that the occurrence of albina mutant was maximum in case of both the varieties. Higher doses (70 KR) of mutagen (gamma ray) were more effective in inducing greater frequencies of chlorophyll mutations in both the cultivars. Chlorophyll mutation frequency was higher in 70 KR gamma rays in both the varieties. Among all the treatment dose of gamma ray, the mutation spectrum in B-1 was much higher than PDM-84-139.

Several types of macro mutation such as dwarf, tall, bushy, creeping/spreading, synchronous maturing type, higher pod length, bold seed and partial sterile and high yielding type were observed in the M₂ generation.

The mean values of these characters studied, of the treated population shifted in positive as well as negative direction over control. The traits like biological yield, pod length, 100 seed weight, seed yield per plant has increased while the characters like plant height was reduced which is most desire trait in case of cultivated pulses in general and in greengram in particular and it is one of the objectives of the present study.

**M₃ generation:**

In M₃ generation, variability in respect of different characters was greater in the treated populations than the control. The result also showed that the same dose of irradiation treatment influenced different characters either in positive or in negative directions. Simple RBD technique of ANOVA was used followed by Duncan’s test at 5% level of significance to compare the means of genotype dose combination at M₃ over parental means (Table 34). It was revealed that PDM-84-139 at 50 KR dose of gamma rays produced maximum biological yield, pod length, seed yield per plant. But pod
number, seeds per pod as well as higher harvest index were noticed in B-1 variety when treated with 50 KR dose. Similarly, branch number per plant, cluster number per plant as well as 100 seed weight were observed maximum in PDM-84-139 at 70 KR. The interaction between dose of treatment and varieties have indicated that for greengram 50 KR dose is most effective to achieve optimum results. Further, careful selection in advanced generations from well planned experiments a few improved lines over their parents as per objectives of the present programme may be identified which will contribute an important role in the improvement of greengram in respect of yield along with other desirable yield attributing characters.

In conclusion, food legumes as a whole a marvel of natural selection must be recognized as crops of very great value in human nutrition, health and in giving meaning to the concept of sustainable agriculture which will be less demanding in terms of fossil fuel based chemicals and will derive great support from renewable resources of energy inputs. A genotype(s) with higher yield potentiality and its sustainability followed by synchronous maturity and tolerance to biotic and abiotic stresses is the urgent demand of the day. And the outcome of further evaluation and identification of the superior types from the selected lines will fulfill this demand.
Chapter – 6

FUTURE SCOPE OF RESEARCH
FUTURE SCOPE OF RESEARCH

Greengram or mungbean [Vigna radiata (L.) Wilczek] is one of the important pulses grown in India either as a kharif or summer crop on varying types of soil and climatic conditions. Yield is unstable both over location and seasons due to susceptibility of the cultivars to environmental stresses (drought or flood), diseases like Mungbean Yellow Mosaic Viruses (MYMV). Although greengram is the third most important pulse in South Asia after chick pea and pigeon pea but the research attention given to this pulse crop is minor compared to cereals and major pulses (Shanmugasundaram, 2003). With the adoption of high yielding cultivars of wheat and rice due to rice wheat cropping system, the area under pulse crop as a whole, has been continuously decreasing. As a result per capita availability of pulses has declined from 69 g day\(^{-1}\) in 1961 to about 36 g day\(^{-1}\) in recent times. As there is little scope of area expansion under pulses, its productivity has to be increased through development of high yielding cultivars with higher adaptability, stability and tolerance to stresses (biotic and abiotic) to meet the present and future requirement of pulses in view of reduce import and saving valuable foreign exchange.

Farmers are reluctant to grow pulses because of their poor yield performance (333 kg/ha in mungbean, 635 kg/ha in pulse crop during 2003-2004 in India). This is due to the cultivation of this high value crop under resource poor condition and partly due to the non-availability of suitable HYV's. In this background, development of mungbean varieties with higher yield potential, greater yield stability and increased production efficiency and synchronous maturity are the foremost task of the present and future genetic enhancement research programme. Various steps are to be taken to achieve the goal, the major ones being interrogation of useful genes from the related wild species, development of ideal plant type with optimum harvest index, exploitation of hybrid vigour through CMS based hybrids, incorporation of multiple and broad based resistance against major diseases. Unlike other crops, the genetic base in pulses including greengram is very narrow. Wider genetic variability is prerequisite for any crop for further improvement. Therefore, in pulses mutagenesis has been an excellent tool for
creating genetic variability for number of oligogenes. Because of narrow genetic variability in cultivated greengram, technique like embryo rescue and creation of genetic variability through mutation breeding will be very much useful in future research programme for the improvement of this important pulse crop. In the present study a few promising lines superior over their parents in respect of good plant type with determinate growth habit, higher number of pods per plant, synchronous and early maturity have been developed and selected. These promising mutants need to be evaluated further under different agro-ecological situations and can be used in the further breeding programme. After careful screening a few promising, superior genotype(s) with desirable yield attributing traits will be available for cultivation.
BIBLIOGRAPHY


Vanitvatanalumlog, N./ Na, Lampang.A./ Sukhapinda, K. and Eksomtramage, T. 
(1986). Induced mutations in mungbean by gamma irradiation. *Improvement of 
grain legume production using induced mutations. Proceedings of a workshop, 


*Bionotes*, 6: 56.

Yadav, R.D.S and Singh, V.P (1986). Mutagenicity of ethyl methane sulphonate and 
gamma rays in mungbean (*Vigna radiata* L. Wilczek). *Pulse Crop Newsl.* 6: 
20-21.

Santosh, I. S. (1965). Reduction of sensitivity to 60 Co gamma rays in *Phaseolus aureus* 

Vishnu Mittre (1962). Palaeobotanical evidence in India; in Evolutionary Studies in 
Worlds Crops. Edited by Sir, Joseph Hutchinson.