Chapter 4

Results
4.1 Analysis of fly-ash, garden soil and fly-ash amended soil

4.1.1 Physico-chemical properties & metal content of fly-ash, garden soil

Observed data related to physico-chemical properties and metals concentrations in fly-ash and garden soil are summarized as Mean ± SD (n=3) and compared by Student t-test are presented in Table A and shown graphically by Fig. a & b respectively. Mean pH and EC in FA were found higher than the GS while mean of CE, total N, total P and OC in GS were higher than the fly-ash. Similarly, mean of CEC, N, P and OC in garden soil was found higher than fly-ash. The mean concentrations of Fe, Cu, Cr, Cd, B, Al and Ni were found in higher concentration in comparison to garden soil, while Zn, Mn, Pb and Mo concentration were found greater in garden soil in comparison of fly-ash. No significant (p>0.05) difference was observed in the mean concentrations of Pb and Cr while rest of the metals was found significantly (p<0.01) different. All physico-chemical parameters were also found significantly different (p<0.01).

4.1.2 Physical properties of different amendments

Five parameters i.e., pH, BD, PD, Porosity and WHC were summarized in Table B and shown graphically by Fig. B. Mean of pH, PD, Porosity and WHC in all the amendments decreases as FA decreases but BD shows an opposite and increasing trend with FA.

Mean of five physical parameters and four amendments were compared together by two-factor analysis of variance (ANOVA) and their significance was done by Newman keuls test (see appendix Table B). Result of ANOVA showed highly significant (p<0.01) difference among parameters. No significant (p>0.05) difference was observed between amendments. Pairwise comparison between parameters of 100% soil and 25% FA + 75% soil shows not significant difference (p>0.05) while 100% FA and in 50% FA + 50% soil, the parameters porosity and WHC were significantly higher (p<0.01) than the pH, BD and PD.

As two way ANOVA shows over all not significant mean difference (p>0.05) among amendments for each parameters, the same were found when compared pair wise by Newman Keuls test.
Table A. Physico-chemical properties and metal contents - Summary-statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Fly-ash</th>
<th>Garden Soil</th>
<th>t-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>9.10 ± 0.46</td>
<td>7.20 ± 0.39</td>
<td>5.46**</td>
</tr>
<tr>
<td>Electrical Conductivity (dSm⁻¹)</td>
<td>7.60 ± 0.38</td>
<td>1.20 ± 0.06</td>
<td>28.81**</td>
</tr>
<tr>
<td>Cation Exchange Capacity [meq (100g)⁻¹]</td>
<td>1.25 ± 0.06</td>
<td>1.59 ± 0.08</td>
<td>5.89**</td>
</tr>
<tr>
<td>Total Nitrogen %</td>
<td>0.02 ± 0.001</td>
<td>1.39 ± 0.07</td>
<td>33.90**</td>
</tr>
<tr>
<td>Total Phosphorus %</td>
<td>0.11 ± 0.04</td>
<td>0.76 ± 0.03</td>
<td>22.52**</td>
</tr>
<tr>
<td>Organic Carbon %</td>
<td>1.16 ± 0.06</td>
<td>1.47 ± 0.07</td>
<td>5.82**</td>
</tr>
<tr>
<td>Metals (µg/g dw)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>4017.00 ± 203</td>
<td>603.58 ± 28.46</td>
<td>28.84**</td>
</tr>
<tr>
<td>Zn</td>
<td>82.27 ± 4.06</td>
<td>108.60 ± 5.31</td>
<td>6.82**</td>
</tr>
<tr>
<td>Mn</td>
<td>69.36 ± 3.47</td>
<td>204.00 ± 10.20</td>
<td>21.64**</td>
</tr>
<tr>
<td>Cu</td>
<td>58.43 ± 2.92</td>
<td>14.50 ± 0.73</td>
<td>25.28**</td>
</tr>
<tr>
<td>Cr</td>
<td>40.32 ± 2.02</td>
<td>36.11 ± 1.81</td>
<td>2.69NS</td>
</tr>
<tr>
<td>Cd</td>
<td>42.51 ± 2.13</td>
<td>27.46 ± 1.40</td>
<td>10.23**</td>
</tr>
<tr>
<td>Pb</td>
<td>40.17 ± 1.99</td>
<td>40.44 ± 2.05</td>
<td>0.16NS</td>
</tr>
<tr>
<td>B</td>
<td>28.95 ± 1.41</td>
<td>10.22 ± 0.51</td>
<td>21.64**</td>
</tr>
<tr>
<td>Al</td>
<td>4851 ± 232</td>
<td>111.29 ± 5.57</td>
<td>35.38**</td>
</tr>
<tr>
<td>Mo</td>
<td>33.32 ± 1.67</td>
<td>40.32 ± 2.02</td>
<td>4.63**</td>
</tr>
<tr>
<td>Ni</td>
<td>204.86 ± 10.20</td>
<td>24.67 ± 1.24</td>
<td>30.37**</td>
</tr>
</tbody>
</table>

NS = not significant (p>0.05), ** = Highly significant (p<0.01)
Table B. Physical properties of different amendments

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Parameters</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>B.D. (g/cc)</td>
<td>P.D. (g/cc)</td>
<td>Porosity (%)</td>
<td>W.H.C. (%)</td>
</tr>
<tr>
<td>100% GS</td>
<td>7.20</td>
<td>1.34</td>
<td>1.76</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>100% FA</td>
<td>9.10</td>
<td>0.9</td>
<td>2.22</td>
<td>59.50</td>
<td>79.50</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>8.00</td>
<td>1.15</td>
<td>1.98</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>7.75</td>
<td>1.23</td>
<td>1.83</td>
<td>33</td>
<td>50</td>
</tr>
</tbody>
</table>

Fig. B. Physical parameters

![Bar chart showing physical parameters for different amendments](chart.png)
4.2 Seed germination

The data pertaining to the effect of fly-ash amended soil on mean germination of *Cajanus cajan* L. is summarized in Table 1 and shown graphically by Fig. 1(a). The seed germination in all the amendments was observed daily from 4 to 10 day. Mean seed germination in all the amendments shows an increasing trend with days. Amendment 25% FA + 75% soil shows the maximum germination and 100% FA the least. ANOVA results indicated highly significant (p<0.01) difference between two factors i.e. days (F = 99.29**) and amendments (F = 16.15**) (see appendix Table 1)

In case of *Cicer arietinum* L., the effect of fly-ash amended soil on mean germination is given in Table 1 and shown graphically by Fig. 1(b). The seed germination in all the amendments was observed daily from 3 to 8 day. Mean seed germination in all the amendments shows an increasing trend with days. Overall, amendment 50% FA + 50% soil shows the maximum germination and 100% FA the least. ANOVA results indicated highly significant (p<0.01) difference between two factors i.e. days (F = 40.49**) and amendments (F = 8.28**) (see appendix Table 1).

4.3 Effect of various fly-ash amendments on growth and some physiological parameters:

4.3.1 Root length

The effect of different amendments of fly-ash on root elongation of *Cajanus cajan* L. is presented in Table 2 and shown graphically by Fig. 2(a). Root length was observed under the effect of four amendments at 30, 60 and 90 days with three replications. During investigation, minimum root length was recorded in 100% FA at 30 days while maximum root length was found in 25% fly-ash amended soil at 90 days. For each amendment, root length increases as day’s increases. ANOVA results indicated highly significant (p<0.01) difference in both factors i.e., days (F=108.60**) and amendments (F=14.06**) (See appendix Table 2). At 30 days, comparison between all amendments was found not significant (p>0.05) difference. At 60 & 90 days, comparison among A vs. C, A vs. D and C vs. D was found not significant (p>0.05) difference and rest were found significant (p<0.05) difference except A vs. B at 90 days that was highly significant (p<0.01) difference. For each
Table 1. Number of seeds germination – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 d</td>
<td>5 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
<td>0.58</td>
</tr>
<tr>
<td>100% FA</td>
<td>4.33</td>
<td>5.00</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>0.58</td>
<td>1.00</td>
<td>0.58</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>7.33</td>
<td>11.00</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>0.58</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>17.33</td>
<td>18.33</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>0.58</td>
<td>1.53</td>
<td>1.00</td>
</tr>
</tbody>
</table>

![Fig. 1 (a) No. of seed germination - Cajanus cajan L.](image1)

![Fig. 1 (b) No. of seed germination - Cicer arietinum L.](image2)
Plate 8: Seed germination of *Cajanus cajan* L. var. ICP 8863 (Maruti) in pots having various fly-ash amendments with soil after 7d.

Plate 9: Seed germination of *Cicer arietinum* L. var. DCP 92-3 in pots having various fly-ash amendments with soil after 7d.
Table 2. Root Length (cm) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>9.26 ± 0.47</td>
<td>14.24 ± 0.72</td>
</tr>
<tr>
<td>100% FA</td>
<td>7.33 ± 0.37</td>
<td>11.50 ± 0.56</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>8.35 ± 0.42</td>
<td>14.70 ± 0.74</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>9.46 ± 0.48</td>
<td>15.10 ± 0.76</td>
</tr>
</tbody>
</table>

Fig. 2 (a) Root length (cm) - Cajanus cajan L.

Fig. 2 (b) Root length (cm) - Cicer arietinum L.
amendment, comparison between 30 days vs. 60 days and 30 days vs. 90 days was found highly significant (p<0.01) difference while comparison between 60 days vs. 90 days was found not significant (p>0.05) difference.

Observed data related to root length of *Cicer arietinum* L. is presented in Table 2 and shown graphically by Fig. 2(b). Maximum root length was found in 50% fly-ash amended soil at 90 days while it was found minimum in 100% garden soil at 30 days. ANOVA results showed highly significant (p<0.01) difference in both factors i.e., days (F=29.28**) and amendments (F=23.74**)(See appendix Table 2). Pair wise comparison was done by Newman Keuls post hoc test separately for each factor. Comparison between C vs. D at 60 days was found highly significant (p<0.01) difference. Comparison between 30 days vs. 60 days for A amendment was found highly significant (p<0.01) difference.

4.3.2 Shoot length

Shoot length of *Cajanus cajan* L. was observed at 30, 60 and 90 days for four amendments that is summarized in Table 3 and shown graphically by Fig. 3(a). Overall maximum shoot growth was recorded in 50% fly-ash amended soil at 90 days while it was found minimum in 100% fly-ash at 30 days. The mean levels of two factors i.e., columns (days) and rows (amendments) were simultaneously analysed by the help of two factors ANOVA. ANOVA results showed highly significant (p<0.01) difference between days (F=83.38**), but significant (p<0.05) difference was observed between amendments (F=12.81*) (See appendix Table 3). Pair wise comparison was done by Newman Keuls post hoc test separately for each factor. Comparison between all amendments at 30 days and comparison between A vs. C, A vs. D, B vs. D and C vs. D at 60 days and 90 days were found not significant (p>0.05) difference and rest were found significant (p<0.05) difference. Comparison between days i.e., 30 days vs. 60 days and 30 days vs. 90 days for each amendment were found highly significant (p<0.01) difference except 30 days vs. 60 days for B amendment, which was found significant (p<0.05) difference. Comparison between 60 days vs. 90 days for each amendment was found not significant (p>0.05) difference.
Table 3. Shoot Length (cm) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><strong>Cajanus cajan</strong> L. ICP 8863 (Maruti)</th>
<th></th>
<th></th>
<th></th>
<th><strong>Cicer arietinum</strong> L. DCP 92-3</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% GS</td>
<td>23.86 ± 1.19</td>
<td>36.11 ± 1.81</td>
<td>43.06 ± 2.15</td>
<td>11.67 ± 0.58</td>
<td>32.00 ± 1.62</td>
<td>36.63 ± 1.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% FA</td>
<td>17.72 ± 0.89</td>
<td>28.50 ± 1.43</td>
<td>34.31 ± 1.72</td>
<td>13.68 ± 0.65</td>
<td>25.00 ± 1.27</td>
<td>29.33 ± 1.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>22.55 ± 1.13</td>
<td>42.51 ± 2.13</td>
<td>44.99 ± 2.26</td>
<td>14.67 ± 0.84</td>
<td>29.33 ± 1.32</td>
<td>33.77 ± 1.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>25.60 ± 1.29</td>
<td>37.61 ± 1.88</td>
<td>43.33 ± 2.17</td>
<td>12.33 ± 0.62</td>
<td>26.33 ± 1.32</td>
<td>30.38 ± 1.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3 (a) Shoot length (cm) - *Cajanus cajan* L.

Fig. 3 (b) Shoot length (cm) - *Cicer arietinum* L.
Table 4. Plant length (cm) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. ICP 8863 (Maruti)</th>
<th><em>Cicer arietinum</em> L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>33.12 ± 1.64</td>
<td>50.35 ± 2.53</td>
</tr>
<tr>
<td>100% FA</td>
<td>25.05 ± 1.29</td>
<td>40.00 ± 1.99</td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>30.90 ± 1.51</td>
<td>57.21 ± 2.87</td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>35.06 ± 1.80</td>
<td>52.71 ± 2.67</td>
</tr>
</tbody>
</table>

Fig. 4 (a) Plant length (cm) - *Cajanus cajan* L.

Fig. 4 (b) Plant length (cm) - *Cicer arietinum* L.
Plate 10: Uprooted plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) grown in various fly-ash amendments for 30 d.

Plate 11: Plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) growing in pots having fly-ash amendments with soil after 30 d of growth.
Plate 12: Uprooted plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) grown in various fly-ash amendments for 60 d.

Plate 13: Plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) growing in pots having fly-ash amendments with soil after 60 d of growth.
Plate 14: Uprooted plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) grown in various fly-ash amendments for 90 d.

Plate 15: Plants of *Cajanus cajan* L. var. ICP 8863 (Maruti) growing in pots having fly-ash amendments with soil after 90 d of growth.
Plate 16: Uprooted plants of *Cicer arietinum* L. var. DCP 92-3 grown in various fly-ash amendments for 30 d.

Plate 17: Plants of *Cicer arietinum* L. var. DCP 92-3 growing in pots having fly-ash amendments with soil after 30 d of growth.
Plate 18: Uprooted plants of *Cicer arietinum* L. var. DCP 92-3 grown in various fly-ash amendments for 60 d.

Plate 19: Plants of *Cicer arietinum* L. var. DCP 92-3 growing in pots having fly-ash amendments with soil after 60 d of growth.
Plate 20: Uprooted plants of *Cicer arietinum* L. var. DCP 92-3 grown in various fly-ash amendments for 90 d.

Plate 21: Plants of *Cicer arietinum* L. var. DCP 92-3 growing in pots having fly-ash amendments with soil after 90 d of growth.
significant (p>0.05) difference. Comparison between 60 days vs. 90 days for each amendment was found not significant (p>0.05) difference but in other cases it was recorded highly significant (p<0.01) difference except the comparison between 30 days vs. 60 days for B amendment that was significant (p<0.05).

4.3.4 Total leaf area

The photosynthetic area of the *Cajanus cajan* L. plant is affected under various fly-ash amendments in a concentration dependent manner. Data of total leaf area is given in Table 5 and shown graphically by Fig. 5(a). Minimum total leaf area was seen in 25% fly-ash amended soil at 30 days while it was maximum in 100% garden soil at 90 days. ANOVA results showed significant (p<0.05) difference between days (F=14.32*) but no significant (p>0.05) difference was observed between amendments (F=3.23NS). Pair wise comparison of each factor was done by Newman Keuls post hoc test. Comparison between all amendments for each day was found not significant (p>0.05) difference. Comparison between days for A & B amendments was found not significant (p>0.05) difference. Comparison between days i.e. 30 days vs. 60 days and 30 days vs. 90 days for C & D amendments was found significant (p<0.05) difference.

In case of *Cicer arietinum* L., Data of total leaf area is given in Table 5 and shown graphically by Fig. 5(b). Maximum total leaf area was recorded in 100% soil at 90 days while it was found minimum in 25% fly-ash amended soil at 30 days. ANOVA results showed highly significant (p<0.01) difference in both the factors i.e. days and amendments. Comparison between some amendments such as B vs. C, B vs. D and C vs. D for each day were recorded not significant (p>0.05) difference, but in rest of comparison between amendments for each day were found significant (p<0.05) except the A vs. B at 90 days which was highly significant (p<0.01) difference. Comparison between 30 days vs. 60 days & 30 days vs. 90 days for C & D amendment and 30 days vs. 90 days for A amendment were observed significant (p<0.05) difference.
Table 5. Total leaf area (cm²) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanuss cajan L. ICP 8863 (Maruti)</th>
<th></th>
<th>Cicer arietinum L. DCP 92-3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>24.28 ± 1.21</td>
<td>28.23 ± 1.42</td>
<td>31.05 ± 1.70</td>
<td>43.33 ± 2.17</td>
<td>55.33 ± 2.77</td>
</tr>
<tr>
<td>100% FA</td>
<td>19.30 ± 0.96</td>
<td>21.56 ± 1.08</td>
<td>23.64 ± 1.18</td>
<td>27.67 ± 1.39</td>
<td>31.67 ± 1.59</td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>17.45 ± 0.82</td>
<td>27.35 ± 1.40</td>
<td>30.23 ± 1.49</td>
<td>25.00 ± 1.26</td>
<td>42.00 ± 2.20</td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>15.35 ± 0.77</td>
<td>26.05 ± 1.30</td>
<td>29.33 ± 1.49</td>
<td>23.00 ± 1.17</td>
<td>39.67 ± 1.98</td>
</tr>
</tbody>
</table>

Fig. 5 (a) Total leaf area (cm²) - *Cajanuss cajan* L.

Fig. 5 (b) Total leaf area (cm²) - *Cicer arietinum* L.
4.3.5 Chlorophyll-a

Coal combustion residue (fly-ash) affect chlorophyll-a content of the plant of *Cajanus cajan* L. which is considered to be the main light harvesting antenna during photosynthesis. The effect of various treatments on chlorophyll-a content of the plant is given in Table 6 and shown graphically by Fig. 6(a). According to Table, the application of lower levels of fly-ash in soil such as 25% fly-ash amended soil were found beneficial for chlorophyll-a content than the content of chlorophyll-a in 100% soil, while 100% fly-ash suppressed the chlorophyll-a content at 30 and 90 days. Chlorophyll-a content was maximum observed in 25% fly-ash amended soil at 90 days and it was minimum in 100% fly-ash at 30 days. ANOVA results showed highly significant (p<0.01) difference between days and no significant (p>0.05) difference was found between amendments (See appendix Table 6). Pair wise result showed that comparison between all amendments for each day was found not significant (p>0.05) difference. Comparison between 30 days vs. 90 days for each amendment was found highly significant (p<0.01) difference.

For *Cicer arietinum* L., Data is summarized in Table 6 and shown graphically by Fig. 6(b). Maximum and Minimum chlorophyll-a content was recorded at 60 days in 25% fly-ash amended soil and in 100% fly-ash, respectively. However, a gradual decline in chlorophyll-a was found in the plant during its increasing growth phases, which might be due to senescence effect on plant reacting to the maturity. According to ANOVA result, highly significant (p<0.01) difference was found between days and no significant (p>0.05) difference was found between amendments. (See appendix Table 6). Newman Keuls multiple comparison tests revealed that comparison between all amendments for each day was found not significant (p>0.05) difference but the comparison between 30 days vs. 90 days for B amendment was found highly significant (p<0.01) difference.

4.3.6 Chlorophyll-b

Although Chlorophyll-b molecules are considered to be accessory pigment participating in production of photosynthesis in plant, it was also affected by different treatments during the present study. The results presented in Table 7 and shown graphically by Fig. 7(a) showed the effect of various fly-
Table 6. Chlorophyll-a (mg g\(^{-1}\) fw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. ICP 8863 (Maruti)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td></td>
</tr>
<tr>
<td>100% GS</td>
<td>1.02 ± 0.05</td>
<td>1.15 ± 0.06</td>
<td>1.25 ± 0.06</td>
<td>1.03 ± 0.05</td>
<td>1.52 ± 0.08</td>
<td>0.91 ± 0.05</td>
<td></td>
</tr>
<tr>
<td>100% FA</td>
<td>0.96 ± 0.04</td>
<td>1.17 ± 0.06</td>
<td>1.18 ± 0.07</td>
<td>1.66 ± 0.08</td>
<td>1.68 ± 0.08</td>
<td>0.55 ± 0.03</td>
<td></td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>1.03 ± 0.05</td>
<td>1.18 ± 0.07</td>
<td>1.32 ± 0.06</td>
<td>1.31 ± 0.06</td>
<td>1.67 ± 0.08</td>
<td>0.62 ± 0.03</td>
<td></td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>1.10 ± 0.05</td>
<td>1.20 ± 0.06</td>
<td>1.33 ± 0.06</td>
<td>1.38 ± 0.06</td>
<td>1.72 ± 0.09</td>
<td>0.77 ± 0.04</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 6 (a) Chlorophyll-a (mg/g fw) – *Cajanus cajan* L.

Fig. 6 (b) Chlorophyll-a (mg/g fw) – *Cicer arietinum* L.
Table 7. Chlorophyll - b (mg g⁻¹ fw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th></th>
<th>Cicer arietinum L. DCP 92-3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
<td>90 d</td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>0.35 ± 0.02</td>
<td>0.45 ± 0.03</td>
<td>0.51 ± 0.03</td>
<td>0.61 ± 0.03</td>
<td>0.70 ± 0.04</td>
</tr>
<tr>
<td>100% FA</td>
<td>0.31 ± 0.01</td>
<td>0.33 ± 0.02</td>
<td>0.35 ± 0.02</td>
<td>0.33 ± 0.02</td>
<td>0.50 ± 0.03</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>0.33 ± 0.02</td>
<td>0.37 ± 0.02</td>
<td>0.42 ± 0.02</td>
<td>0.35 ± 0.02</td>
<td>0.56 ± 0.03</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>0.37 ± 0.02</td>
<td>0.39 ± 0.02</td>
<td>0.50 ± 0.03</td>
<td>0.37 ± 0.02</td>
<td>0.57 ± 0.03</td>
</tr>
</tbody>
</table>

Fig. 7 (a) Chlorophyll-b (mg/g fw) - *Cajanus cajan* L.

- 100% Soil
- 100% FA
- 50% FA + 50% Soil
- 25% FA + 75% Soil

Fig. 7 (b) Chlorophyll-b (mg/g fw) - *Cicer arietinum* L.

- 100% Soil
- 100% FA
- 50% FA + 50% Soil
- 25% FA + 75% Soil
ash amendments at different treatment duration of *Cajanus cajan* L. Chlorophyll-b content was maximum in 100% soil at 90 days and it was minimum in 100% fly-ash at 30 days. ANOVA results showed significant (p<0.05) difference in both factors i.e., days and amendments. (See appendix Table 7). Comparison between A vs. B and B vs. D for 90 day were found significant (p<0.05) difference but in rest of comparison between amendments for each day were observed not significant (p>0.05) difference. Comparison between 30 days vs. 90 days for A amendment and 30 days vs. 90 for D amendment were found significant (p<0.05) difference but in other cases, it was not significant (p>0.05) difference.

Chlorophyll-b content of *Cicer arietinum* L. is given in Table 7 and shown graphically by Fig. 7(b). In this case it is interesting to note that although fly-ash had inhibited chlorophyll-b of the plant, it increased in various levels of fly-ash supplementation of the soil. ANOVA results showed highly significant (p<0.01) difference in both the factors i.e., days and amendments. (See appendix Table 7). Comparison between B vs. C, B vs. D and C vs. D for each day was found not significant (p>0.05). At 30 day, comparison between A vs. B, A vs. C and A vs. D were found highly significant (p<0.01) difference but at 60 day and 90 day, it was found significant (p<0.05) difference. Comparison between 30 days vs. 60 days for A amendment was found not significant (p>0.05) difference but in rest of cases for each amendment it was found highly significant (p<0.01) difference. Comparison between 30 days vs. 90 days for D amendment was found significant (p<0.05) difference.

4.3.7 Total Chlorophyll

The effect of various fly-ash amendments at different growth phases of the *Cajanus cajan* L. plant on total chlorophyll content is given in Table 8 and shown graphically by Fig. 8(a). Since, total chlorophyll content of the plant is a sum of chlorophyll-a and b it’s content was also affected by various fly-ash amendments with soil. Total chlorophyll content was found maximum in 25% fly-ash amended soil at 90 days while it was minimum in 100% fly-ash at 30 days. Two-way ANOVA results showed highly significant (p<0.01) difference between days, but significant (p<0.05) difference was found between
Table 8. Total Chlorophyll content (mg g⁻¹ fw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>1.37 ± 0.07</td>
<td>1.59 ± 0.08</td>
</tr>
<tr>
<td>100% FA</td>
<td>1.26 ± 0.06</td>
<td>1.49 ± 0.07</td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>1.35 ± 0.07</td>
<td>1.56 ± 0.07</td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>1.47 ± 0.07</td>
<td>1.58 ± 0.07</td>
</tr>
</tbody>
</table>

**Fig. 8 (a) Total chlorophyll (mg/g fw) - Cajanus cajan L.**

**Fig. 8 (b) Total chlorophyll (mg/g fw) - Cicer arietinum L.**
amendments. Comparison between all amendments at 30 and 60 days were observed not significant (p>0.05) difference and at 90 days, A vs. B, B vs. C and B vs. D were found significant (p<0.05) difference and A vs. C, A vs. D and C vs. D were found not significant (p>0.05) difference. Comparison between 30 days vs. 60 days for D amendment was found not significant (p>0.05) difference while comparison between 30 days vs. 90 days for A, C and D amendments were found highly significant (p<0.01) difference. Comparison between 60 days vs. 90 days for each amendment was found significant (p<0.05) difference. For A, B and C amendments, comparison between 30 days vs. 60 days was found significant (p<0.05) difference and comparison between 30 days vs. 90 days for B amendment was also observed significant (p<0.05) difference.

For *Cicer arietinum* L., data of the total chlorophyll content is given in Table 8 and shown graphically by Fig. 8(b). Total chlorophyll content increased up to 60 days of growth and a decrease was found at 90 days in all the treatments. ANOVA results showed highly significant (p<0.01) difference between days but no significant (p>0.05) difference was found between amendments. Comparison between all amendments for each day was observed not significant (p>0.05) difference. Comparison between 30 days vs. 60 days for each amendment was found not significant (p>0.05) difference. Comparison between 30 days vs. 90 days for A amendment was also found not significant (p>0.05) difference. Comparison between 60 days vs. 90 days for B, C and D amendments were found highly significant (p<0.01) difference and comparison between 30 days vs. 90 days for B amendment was also found highly significant (p<0.01) difference. Comparison between 30 days vs. 90 days for C & D amendment and 60 days vs. 90 days for A amendment were found significant (p<0.05) difference.

4.3.8 Number of nodules/plant

Nodule is an important part of root where major microbes live and conduct N fixation and other important functions for plant growth. Data of nodule of *Cajanus cajan* L. plant is given in Table 9 and shown graphically by Fig. 9(a). Fly-ash not only affected the growth of the plant but also had a great influence on the nodulation of the plant, which are considered the site of N₂ –
Table 9. Number of nodules per plant – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>11.00 ± 0.56</td>
<td>13.67 ± 0.67</td>
</tr>
<tr>
<td>100% FA</td>
<td>8.43 ± 0.28</td>
<td>10.16 ± 0.37</td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>12.33 ± 0.62</td>
<td>13.33 ± 0.65</td>
</tr>
<tr>
<td>25% FA+75% GS</td>
<td>14.00 ± 0.71</td>
<td>15.33 ± 0.77</td>
</tr>
</tbody>
</table>

Fig. 9 (a) Number of nodules/plant - *Cajanus cajan* L.

Fig. 9 (b) Number of nodules/plant - *Cicer arietinum* L.
fixation. Minimum number of nodule was recorded in 100% fly-ash at 30 days while it was maximum in 100% soil at 90 days. ANOVA results revealed highly significant (p<0.01) difference in both the factors i.e. days and amendments (See appendix Table 9). Pair wise comparison between amendments i.e. A vs. B, A vs. C, A vs. D and B vs. C for 30 and 60 days were recorded not significant (p>0.05) difference. Comparison between C vs. D for each day and A vs. C, A vs. D for 90 days were found not significant (p>0.05) difference. Comparison between B vs. D for 90 days was found higher significant (p<0.01) difference. Comparison between B vs. D at 30 and 60 days were found significant (p<0.05) difference. Comparison between 30 days Vs. 90 days and 60 days vs. 90 days for A amendment were found highly significant (p<0.01) difference.

Data related to nodule of Cicer arietinum L. plant is summarised in Table 9 and shown graphically by Fig. 9(b). Number of nodules was decreased in 100% fly-ash in comparison of garden soil and it was increased in 25% fly-ash amended soil in comparison of garden soil. Minimum nodules were observed in 100% fly-ash at 30 days while it was maximum in 25% fly-ash amended soil at 90 days. ANOVA results revealed highly significant (p<0.01) difference in both the factors i.e., days and amendments. (See appendix Table 9). Pair wise comparison between A vs. B and B vs. D for each day and B vs. C for 60 and 90 days were found highly significant (p<0.01) difference. Comparison between A vs. C and A vs. D for each day was observed not significant (p>0.05) difference. All comparison between days for each amendment was found highly significant (p<0.01) difference.

4.3.9 Biomass

The effect of different fly-ash amendments on biomass of Cajanus cajan L. at various treatment durations is presented in Table 10 and shown graphically by Fig. 10(a). According to table, Biomass was reduced in 100% fly-ash at 30, 60 and 90 days in comparison of 100% garden soil and later on it was increased in 50% and 25% fly-ash amended soil respectively. Maximum biomass was produced in 100% soil at 90 days while it was minimum in 100% fly-ash at 30 days. ANOVA results revealed that variation in biomass was found highly significant (p<0.01) difference between days but it was found
Table 10. Biomass (g dw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. ICP 8863 (Maruti)</th>
<th><em>Cicer arietinum</em> L. DCP 92-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 d</td>
<td>60 d</td>
</tr>
<tr>
<td>100% GS</td>
<td>3.12 ± 0.16</td>
<td>6.63 ± 0.33</td>
</tr>
<tr>
<td>100% FA</td>
<td>2.63 ± 0.13</td>
<td>4.59 ± 0.23</td>
</tr>
<tr>
<td>50% FA+50% GS</td>
<td>3.52 ± 0.18</td>
<td>5.82 ± 0.29</td>
</tr>
<tr>
<td>25% FA+ 75% GS</td>
<td>3.67 ± 0.19</td>
<td>6.25 ± 0.32</td>
</tr>
</tbody>
</table>

Fig. 10 (a) Biomass (g dw) - *Cajanus cajan* L.

Fig. 10 (b) Biomass (g dw) - *Cicer arietinum* L.
significantly $(p<0.05)$ difference between amendments. (See appendix Table 10). Comparison between all amendments for each day were found not significant $(p>0.05)$ difference except comparison between A vs. B and B vs. D for 60 days which were found significant $(p<0.05)$ difference. All comparison between days for each amendment was recorded highly significant $(p<0.01)$ difference.

Data related to biomass of *Cicer arietinum* L. is given in Table 10 and shown graphically by Fig. 10(b). Minimum biomass was found in 100% garden soil at 30 days while maximum biomass was found in 25% fly-ash amended soil at 90 days. ANOVA results revealed that variation in biomass was found significant $(p<0.05)$ difference between days, while it was not significant $(p>0.05)$ difference between amendments. (See appendix Table 10). Pair wise comparison between all amendments for each day was found not significant $(p>0.05)$ difference. All pair wise comparison between days for A and B amendments was found not significant $(p>0.05)$ difference. Comparison between 30 days vs. 60 days for C and D amendments and comparison between 30 days vs. 90 days for C amendment were found not significant $(p>0.05)$ difference. Comparison between 60 days vs. 90 days for C and D amendments and comparison between 30 days vs. 90 days for D amendment were found significant $(p<0.05)$ difference.

### 4.4 Metal accumulation in different parts of plant under various fly-ash amendments

#### 4.4.1 Metal accumulation in shoots

Metal accumulation in shoots of *Cajanus cajan* L., harvested on different concentration of fly-ash at maturity is given in Table 11 and shown graphically by Fig. 11(a). In shoots, concentration of Fe was higher that other metals. Minimum accumulations of all metals were found in 100% soil while maximum accumulation of all metals was observed in 25% fly-ash amended soil. Two way ANOVA revealed that there was a highly significant $(p<0.01)$ difference among metals (see appendix Table 11). Pair wise comparison showed no significant $(p>0.05)$ difference among metals in A amendment. In B, C, and D amendments Fe was found significantly $(p<0.01)$ higher than Zn,
Table 11. Metal accumulation in shoots (μg g⁻¹ dw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. ICP 8863 (Maruti)</th>
<th><em>Cicer arietinum</em> L. DCP 92-3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe</td>
<td>Zn</td>
</tr>
<tr>
<td>100% GS</td>
<td>75.31</td>
<td>8.69</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>3.80</td>
<td>0.43</td>
<td>0.55</td>
</tr>
<tr>
<td>100 % FA</td>
<td>281.61</td>
<td>35.55</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>14.17</td>
<td>1.80</td>
<td>0.98</td>
</tr>
<tr>
<td>50 % FA + 50% GS</td>
<td>267.10</td>
<td>30.80</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>13.30</td>
<td>1.55</td>
<td>0.91</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>309.76</td>
<td>39.58</td>
</tr>
<tr>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>15.38</td>
<td>1.98</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Fig. 11 (a) Metals in shoots (μg/g dw) - *Cajanus cajan* L.
Fig. 11 (b) Metals in shoots (μg/g dw) - *Cicer arietinum* L.
Cu, Cr and Cd while the mean difference among Zn, Cu, Cr and Cd were found not significant (p>0.05).

Metal accumulation in shoots of *Cicer arietinum* L., harvested from different concentration of fly-ash at maturity is presented in Table 11 and shown graphically by Fig. 11(b). According to table, concentration of Fe metal in shoot accumulation was higher than other metals. Minimum accumulation of all metals except Zn found in 100% soil while Zn was found in 50% fly-ash amended soil, but maximum accumulation of all metals were found in 25% fly-ash amended soil. Two way ANOVA showed that there was a highly significant (p<0.01) difference among metals (see appendix Table 11). Pair wise comparison among metals revealed that in all amendments Fe was found significantly (p<0.01) higher than the Zn, Cu, Cr and Cd while the mean difference among Zn, Cu, Cr and Cd in A and C amendments were found not significant (p>0.05).

4.4.2 Metal accumulation in roots

Metal accumulation in roots of *Cajanus Cajan* L., harvested from different concentration of fly-ash at maturity is summarized in Table 12 and shown graphically by Fig. 12(a). According to table, concentration of Fe metal in roots was higher than other metals. Minimum accumulation of all metals was found in 100% soil while maximum accumulation of all metals was recorded in 25% fly-ash amended soil. Two way ANOVA revealed that there was a highly significant (p<0.01) difference among metal concentrations (see appendix Table 12). Pair wise comparison was done by Newman Keuls post hoc Test. Pair wise comparison showed no significant (p>0.05) difference among metals in A amendments. In B and D amendments Fe metal was found significantly (p<0.01) higher than Zn, Cu and Cr. In C amendment Fe metal was found significantly (p<0.01) higher than Cu metal. The mean difference among Zn, Cu, Cr and Cd in B, C and D amendments were found not significant (p>0.05).

Data of metal accumulation in roots of *Cicer arietinum* L. is presented in Table 12 and shown graphically by Fig. 12(b). According to table, concentration of Fe metal in roots was higher than other metals. Minimum accumulation for Fe, Cr and Cd metal were found in 100% soil, but in case of
Table 12. Metal accumulation in roots (µg g⁻¹ dw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe</td>
<td>Zn</td>
</tr>
<tr>
<td>100% GS</td>
<td>116.23</td>
<td>± 12.10</td>
</tr>
<tr>
<td>± 5.47</td>
<td>± 0.62</td>
<td>± 0.77</td>
</tr>
<tr>
<td>100 % FA</td>
<td>665.75</td>
<td>± 51.16</td>
</tr>
<tr>
<td>± 33.31</td>
<td>± 2.56</td>
<td>± 3.71</td>
</tr>
<tr>
<td>50 % FA + 50% GS</td>
<td>581.45</td>
<td>± 28.23</td>
</tr>
<tr>
<td>± 28.97</td>
<td>± 1.42</td>
<td>± 2.51</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>716.33</td>
<td>± 35.02</td>
</tr>
<tr>
<td>± 35.02</td>
<td>± 2.87</td>
<td>± 4.20</td>
</tr>
</tbody>
</table>

Fig. 12 (a) Metals in roots (µg/g dw) - *Cajanus cajan* L.

- 100% Soil
- 100% FA
- 50% FA + 50% Soil
- 25% FA + 75% Soil

Fig. 12 (b) Metals in roots (µg/g dw) - *Cicer arietinum* L.

- 100% Soil
- 100% FA
- 50% FA + 50% Soil
- 25% FA + 75% Soil
Zn and Cu metal, minimum accumulation was recorded in 50% fly-ash amended soil while maximum accumulation of all metals were found in 25% fly-ash amended soil. Two way ANOVA showed that there was a highly significant (p<0.01) difference among metals (see appendix Table 12) Pair wise comparison among metals revealed that in all amendments Fe was found significantly (p<0.01) higher than Zn, Cu and Cr. In B, C and D amendments Fe was found significantly (p<0.01) higher than the Cd. The mean difference among Zn, Cu, Cr and Cd in all amendments was found not significant (p>0.05).

4.4.3 Metal accumulation in Seeds

Metal accumulation in seeds of *Cajanus cajan* L., produced from different concentration of fly ash is summarized in Table 13 and shown graphically by Fig. 13(a). According to Table, concentration of Fe metal in seeds was higher than other metals. Minimum concentration of all metals was found in 100% garden soil. Maximum concentration for Fe, Zn, Cu and Cr metals in seeds was found in 25% fly ash amended soil but in case of Cd metal, it was maximum in 100% Fly ash. Two ways ANOVA revealed that there was a highly significant (p<0.01) difference among metals (see appendix Table 13). Pair wise comparison showed no significant (p>0.05) difference among metals in A amendment. In B, C, and D amendments Fe was found significantly (p<0.01) higher than Zn, Cu, Cr and Cd while the mean difference among Zn, Cu, Cr and Cd were found not significant (p>0.05).

Metal accumulation in seeds of *Cicer arietinum* L., produced in different concentration of fly-ash is summarized in Table 13 and shown graphically by Fig. 13(b). According to result of mean ± SD, concentration of Fe metal in seed was higher than other metals. Minimum accumulation for Fe, Zn and Cd were found in 50% fly-ash amended soil, but in rest of metals, minimum accumulation were recorded in 100% soil. Maximum accumulation for Fe, Zn, Cu and Cr were found in 25% fly-ash amended soil while in Cd metal, it was maximum in 100% soil. Two way ANOVA showed that there was a highly significant (p<0.01) difference among metals (see appendix Table 13). Pair wise comparison showed no significant (p>0.05) difference among metals in A and C amendments. In B and C amendments Fe was found
Table 13. Metal accumulation in seeds (µg g⁻¹ dw) – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th></th>
<th>Cicer arietinum L. DCP 92-3.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fe</td>
<td>Zn</td>
<td>Cu</td>
<td>Cr</td>
</tr>
<tr>
<td>100% GS</td>
<td>41.57</td>
<td>6.33</td>
<td>8.08</td>
<td>1.23</td>
</tr>
<tr>
<td>± 2.10</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>100% FA</td>
<td>158.49</td>
<td>27.35</td>
<td>17.33</td>
<td>3.36</td>
</tr>
<tr>
<td>± 3.24</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>149.22</td>
<td>16.58</td>
<td>16.67</td>
<td>4.23</td>
</tr>
<tr>
<td>± 0.72</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>173.50</td>
<td>31.24</td>
<td>19.03</td>
<td>6.25</td>
</tr>
<tr>
<td>± 8.73</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
</tbody>
</table>

Fig. 13 (a) Metals in seeds (µg/g dw) - Cajanus cajan L.

<table>
<thead>
<tr>
<th>METALS</th>
<th>100% Soil</th>
<th>100% FA</th>
<th>50% FA + 50% Soil</th>
<th>25% FA + 75% Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 13 (b) Metals in seeds (µg/g dw) - Cicer arietinum L.

<table>
<thead>
<tr>
<th>METALS</th>
<th>100% Soil</th>
<th>100% FA</th>
<th>50% FA + 50% Soil</th>
<th>25% FA + 75% Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cd</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
significantly (p<0.01) higher than the Zn, Cu, Cr and Cd while mean difference among Zn, Cu, Cr and Cd were found not significant (p>0.05).

4.5 Effect of various fly-ash amendments on the yield of plants

4.5.1 Number of pods/plant

The effect of various fly-ash amendments on number of pods/plant of *Cajanus cajan* L. is given in Table 14 and shown graphically by Fig. 14(a). According to table, minimum number of pods/plant was counted in 100% fly-ash, while it was maximum in 25% fly-ash amended soil. The mean difference in pods/plant of *Cajanus cajan* L. between each amendments was analysed by one way ANOVA (See appendix Table 14). ANOVA results showed (F=57.79**) overall highly significant (p<0.01) difference in their mean levels. To know which pair differs in their mean level pair wise post hoc test was done by Newman Keuls test. No significant (p>0.05) difference was observed among A vs. C, A vs. D and C vs. D, but in other comparison it was found highly significant (p<0.01) difference.

Data of pods/plant of *Cicer arietinum* L. is presented in Table 14 and shown graphically by Fig. 14(b). According to table, minimum number of pods/plant was counted in 100% fly-ash, while maximum number of pods/plant was counted in 50% fly-ash amended soil. One-way ANOVA summary showed highly significant (p<0.01) difference between amendments for no. of pods/plant. According to pair wise comparison, no significant (p>0.05) difference was observed between A and C, while in comparison of A vs. B, B vs. C and B vs. D was found highly significant (p<0.01) difference, but in rest of two cases, it was found significant (p<0.05) difference.

4.5.2 Total soluble protein contents in seeds

The total soluble protein contents in seeds of *Cajanus cajan* L. in different fly-ash amendments is summarized in Table 15 and shown graphically by Fig. 15(a). According to table, minimum total soluble protein contents in seeds were recorded in 50% fly-ash amended soil while it was maximum in 25% fly-ash amended soil. One-way ANOVA summary showed highly significant (p<0.01) difference between amendments for protein content in seeds. (See appendix Table 15). According to pair wise comparison,
Table 14. Number of pods per plant – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>Cajanus cajan L. ICP 8863 (Maruti)</th>
<th>Cicer arietinum L. DCP 92-3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 Days</td>
<td>90 Days</td>
</tr>
<tr>
<td>100% GS</td>
<td>35.04 ± 1.75</td>
<td>12.00 ± 0.61</td>
</tr>
<tr>
<td>100% FA</td>
<td>21.64 ± 1.08</td>
<td>7.33 ± 0.37</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>35.55 ± 1.80</td>
<td>12.33 ± 0.61</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>37.53 ± 1.88</td>
<td>10.67 ± 0.49</td>
</tr>
</tbody>
</table>

Fig. 14 (a) Number of pods/plant - Cajanus cajan L.

Fig. 14 (b) Number of pods/plant - Cicer arietinum L.
Table 15. Total soluble protein (mg g\(^{-1}\) dw) in seed – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th>\textit{Cajanuss cajan} L. ICP 8863 (Maruti)</th>
<th>\textit{Cicer arietinum} L. DCP 92-3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90 Days</td>
<td>90 Days</td>
</tr>
<tr>
<td>100% GS</td>
<td>42.80 ± 2.10</td>
<td>44.60 ± 2.20</td>
</tr>
<tr>
<td>100% FA</td>
<td>35.83 ± 1.75</td>
<td>38.86 ± 1.90</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>34.14 ± 1.70</td>
<td>36.30 ± 1.80</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>43.99 ± 2.20</td>
<td>45.60 ± 2.30</td>
</tr>
</tbody>
</table>

Fig. 15 (a) Total soluble protein (mg/g dw) in seeds - \textit{Cajanuss cajan} L.

Fig. 15 (b) Total soluble protein (mg/g dw) in seeds - \textit{Cicer arietinum} L.
no significant (p>0.05) difference was observed between A vs. D and B vs. C, but in rest of comparison, it was found highly significant (p<0.01) difference.

For *Cicer arietinum* L., the data of total soluble protein contents in seeds is given in Table 15 and shown graphically by Fig. 15(b). According to table, minimum total soluble protein contents in seeds were recorded in 50% fly-ash amended soil, while it was maximum in 25% fly-ash amended soil. One-way ANOVA summary showed highly significant (p<0.01) difference between amendments for total soluble protein contents in seeds. (See appendix Table A15). On the basis of pair wise comparison, no significant (p>0.05) difference was observed between A vs. D and B vs. C, but in rest of comparison, it was found highly significant (p<0.01) difference.

### 4.5.3 Seed weight

Effect of various fly-ash amendments on seed weight of *Cajanus cajan* L. is summarized in Table 16 and shown graphically by Fig. 16(a). On the basis of table, minimum weight of 25 seeds i.e. 2.13g were recorded in 100% fly-ash, while maximum weight of 25 seeds i.e. 2.73g were recorded in 25% fly-ash amended soil. One-way ANOVA summary showed highly significant (p<0.01) difference between amendments for weight of 25 seeds. No significant (p>0.05) difference was observed between A vs. B, A vs. C and B vs. C, but in rest of three comparison, A vs. D and B vs. D was observed highly significant (p<0.01) difference while comparison between C vs. D was recorded significant (p<0.05) difference.

In case of *Cicer arietinum* L., effect of different concentration of fly-ash on seed weight is given in Table 16 and shown graphically by Fig. 16(b). Maximum weight of 25 seeds i.e. 4.97g was recorded in 25% fly-ash amended soil, while it was minimum recorded in 100% fly-ash. ANOVA results showed significant (p<0.05) difference between amendments for weight of 25 seeds. On the basis of pair wise comparison, not significant (p>0.05) difference was observed between A vs. B, A vs. C, A vs. D and B vs. C, but in rest of comparison, it was found significant (p<0.05) difference.

**Relative mean yield increase (%) for 25 seeds weight.**

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. (%)</th>
<th><em>Cicer arietinum</em> L. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A to D</td>
<td>14.23</td>
<td>16.94</td>
</tr>
<tr>
<td>B to D</td>
<td>28.17</td>
<td>38.44</td>
</tr>
<tr>
<td>C to D</td>
<td>15.68</td>
<td>29.43</td>
</tr>
</tbody>
</table>
Table 16. Weight of 25 seeds – Summary statistics (Mean ± SD, n=3)

<table>
<thead>
<tr>
<th>Amendments</th>
<th><em>Cajanus cajan</em> L. ICP 8863 (Maruti)</th>
<th><em>Cicer arietinum</em> L. DCP 92-3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight of 25 seeds (g)</td>
<td>Weight of 25 seeds (g)</td>
</tr>
<tr>
<td>100% GS</td>
<td>2.39 ± 0.11</td>
<td>4.25 ± 0.47</td>
</tr>
<tr>
<td>100% FA</td>
<td>2.13 ± 0.10</td>
<td>3.59 ± 0.52</td>
</tr>
<tr>
<td>50% FA + 50% GS</td>
<td>2.36 ± 0.12</td>
<td>3.84 ± 0.37</td>
</tr>
<tr>
<td>25% FA + 75% GS</td>
<td>2.73 ± 0.14</td>
<td>4.97 ± 0.34</td>
</tr>
</tbody>
</table>

Fig. 16 (a) Weight of 25 seeds (g) - *Cajanus cajan* L.

Fig. 16 (b) Weight of 25 seeds (g) - *Cicer arietinum* L.