Irrigation management on growth, yield and quality of chickpea (Cicer arietinum L.)

Nagesh Lende and Hemant Patil

Abstract
An experiment entitled “Irrigation management for chickpea (Cicer arietinum L.)” was conducted during rabi season 2010-11 at Pulses Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (Maharashtra). In order to fulfill the objectives of the experiment seven treatments with three replications were laid out in randomized block design. The seed of deshi chickpea cv. Digvijay were dibbled at 30x10 cm spacing for ridges and furrows layout. Sowing was done on 28th October, 2010. The relationship between yield of Digvijay chickpea, water use efficiency and consumptive use of water were determined. The differences due to irrigation treatments were found to be significant in respect to the growth parameters of chickpea were significantly higher when irrigation given at branching and pod development stage with furrows irrigation, while these parameters were decreased significantly when irrigated at flowering followed by branching stage. The yield attributes, seed and straw yield of chickpea per hectare were significantly highest when irrigation applied at branching and pod development stage with all furrows irrigated. The seed yield was significantly higher (26.92 q ha⁻¹) when irrigation given at branching and pod development stage with all furrows irrigated (T⁶), but it was decreased as number and quantity of irrigation reduced. The growth functions viz., absolute growth rate, net assimilation rate, crop growth rate were significantly higher when irrigation applied at branching and pod development stage with all furrows irrigated as compared to others. The quality parameters like protein content (23.80 %) and protein yield (6.41 q ha⁻¹) were significantly higher due to irrigation at branching and pod development stage with all furrows irrigated followed by irrigation given at pod development stage with all furrows irrigated (22.81 and 5.30 q ha⁻¹). The higher water use efficiency was recorded when irrigation given at pod development stage with all furrows irrigated (102.51 kg ha⁻¹ cm) as compared to other irrigation treatments. Irrigation scheduling at branching and pod development stage with all furrows irrigated (T⁶) recorded higher gross monetary return (Rs.82558 ha⁻¹), net monetary return (Rs. 55,308 ha⁻¹) and benefit cost ratio (3.03) than rest of the treatments.

Keywords: irrigation, growth, yield, quality, chickpea

Introduction
Chickpea (Cicer arietinum L.) is the most important pulse crop in India. Chickpea is cultivated on 7.54 million ha area with 6.13 million tones production with 812 kg ha⁻¹ productivity in the 19th century. Chickpea is the second most important pulse crop cultivated in rabi season in Maharashtra covering 22.47 per cent of the total area (13.32 lakh ha) and 21.88 per cent production of the state (12.44 lakh tones) with 935 kg ha⁻¹ productivity. The existing level of chickpea production in the state is lower than its potential (5 t ha⁻¹). Several biotic and abiotic stresses lead to low productivity. However, a major breakthrough in productivity of chickpea is yet to be witnessed. There are many factors viz., environment, agronomy and socio-economic which are responsible for poor productivity of chickpea in the state. Irrigation scheduling technique at critical growth stages assumes greater significance. Critical growth period is a stage of growth of plant at which moisture stress exercises the greatest influence on both the quantity and quality of produce. In Maharashtra, productivity of chickpea is very low owing to limited soil moisture in rabi season, shorter winter season, negligible adoption of improved agro technologies as well as minimum use of inputs. This might be because of the good soil moisture availability, soil aeration, microbial activity, water drainage, nutrient availability, etc. Chickpea is one of the most important rabi pulse crop in Asia. India is largest producer (25 %), importer (20 %) and consumer (27 %) of Pulses in the world. Therefore, it is felt necessary to develop the technology for yield maximization of Deshi chickpea regarding irrigation technique and critical stages of crop.

Material and Methods
The field experiment was conducted during rabi 2010-11 at Pulse Improvement Project, M.P.K.V., Rahuri.
The experiment was laid out in Randomized Block Design with three replications and seven treatments. The experimental gross plot size consists of 5.00 x 4.20 m² and net plot was 4.60 x 3.60 m². The details of treatment with symbols.

Table 1

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Symbol used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No irrigation (control)</td>
<td>T₁</td>
</tr>
<tr>
<td>2</td>
<td>Irrigation at branching : All furrows</td>
<td>T₂</td>
</tr>
<tr>
<td>3</td>
<td>Irrigation at branching : Alternate furrows</td>
<td>T₃</td>
</tr>
<tr>
<td>4</td>
<td>Irrigation at pod development stage : All furrows</td>
<td>T₄</td>
</tr>
<tr>
<td>5</td>
<td>Irrigation at pod development stage : Alternate furrows</td>
<td>T₅</td>
</tr>
<tr>
<td>6</td>
<td>Irrigation at branching and Pod development stage : All furrows</td>
<td>T₆</td>
</tr>
<tr>
<td>7</td>
<td>Irrigation at branching and Pod development stage : Alternate furrows</td>
<td>T₇</td>
</tr>
</tbody>
</table>

Table 2: Mean plant height as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Plant height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>30 DAS</td>
</tr>
<tr>
<td>T₁</td>
<td>No Irrigation</td>
<td>18.70</td>
</tr>
<tr>
<td>T₂</td>
<td>Irrigation at Branching : All furrows</td>
<td>18.60</td>
</tr>
<tr>
<td>T₃</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>17.90</td>
</tr>
<tr>
<td>T₄</td>
<td>Irrigation at Pod development stage : All furrows</td>
<td>19.30</td>
</tr>
<tr>
<td>T₅</td>
<td>Irrigation at Pod development stage : Alternate furrows</td>
<td>17.90</td>
</tr>
<tr>
<td>T₆</td>
<td>Irrigation at Branching and Pod development stage : All furrows</td>
<td>19.90</td>
</tr>
<tr>
<td>T₇</td>
<td>Irrigation at Branching and Pod development stage : Alternate furrows</td>
<td>18.40</td>
</tr>
<tr>
<td>General Mean</td>
<td></td>
<td>18.67</td>
</tr>
<tr>
<td>S.E. ±</td>
<td></td>
<td>0.35</td>
</tr>
<tr>
<td>CD at 5 %</td>
<td></td>
<td>1.08</td>
</tr>
<tr>
<td>CV %</td>
<td></td>
<td>3.27</td>
</tr>
</tbody>
</table>
### Table 3: Mean no. of primary branches/plant as influenced by different irrigation treatmt.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Treatment</th>
<th>Number of primary branches per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>2.10</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>2.20</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>2.50</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>2.40</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>2.00</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>3.50</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>General Mean</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>S.E.</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>CD at 5 %</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>CV %</td>
<td>14.04</td>
</tr>
</tbody>
</table>

### Table 4: Mean plant spread as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Treatment</th>
<th>Plant spread (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>11.00</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>12.93</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>13.47</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>14.00</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>13.53</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>16.00</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>17.33</td>
</tr>
<tr>
<td></td>
<td>General Mean</td>
<td>14.04</td>
</tr>
<tr>
<td></td>
<td>S.E.</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>CD at 5 %</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>CV %</td>
<td>18.52</td>
</tr>
</tbody>
</table>

The highest dry matter (35.80 g plant$^{-1}$) at harvest was recorded by the treatment comprises irrigation at branching and pod development stage with all furrows irrigated. These results are in accordance with Dixit et al. (1993), Krishnamurthy and Steermanulu (2007), Yadav (2009).

### Table 5: Dry matter per plant as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Treatment</th>
<th>Dry matter per plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
</tr>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>0.74</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>0.73</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>0.67</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>0.71</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>0.68</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>0.72</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>General Mean</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>S.E.</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>CD at 5 %</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>CV %</td>
<td>5.31</td>
</tr>
</tbody>
</table>

Weight of root nodules per plant (mg)

At 45 DAS, irrigation at branching and pod development stage: all furrows irrigated recorded significantly highest weight of nodules (0.75 mg plant$^{-1}$) which was at par with the treatment T6 (0.67 mg plant$^{-1}$) comprises irrigation at pod development stage: all furrows irrigated. Similar results were observed by Saxena et al. (1990) [5], Dixit et al. (1993) Chanegra and Yadavendra (1998), Reddy et al. (2004).

### Table 6: Number of root nodules and their weight per plant as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Treatment</th>
<th>Number of root nodules (45 DAS)</th>
<th>Weight of root nodules (mg) (45 DAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>15.60</td>
<td>0.51</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>19.50</td>
<td>0.63</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>18.30</td>
<td>0.57</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>20.20</td>
<td>0.67</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>18.20</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Number of root nodules

At 45 DAS, irrigation at branching and pod development stage: all furrows irrigated recorded highest root nodules (8.60) than rest of the treatments. Whereas, at pod development stage, significantly highest (22.60 plant$^{-1}$) root nodule was recorded in the treatment T6.

At 45 DAS, irrigation at branching and pod development stage: all furrows irrigated recorded significantly highest weight of nodules (0.75 mg plant$^{-1}$) which was at par with the treatment T6 (0.67 mg plant$^{-1}$) comprises irrigation at pod development stage: all furrows irrigated. Similar results were observed by Saxena et al. (1990) [5], Dixit et al. (1993) Chanegra and Yadavendra (1998), Reddy et al. (2004).
Yield and Yield contributing characters

Number of pods per plant
The number of pods per plant was recorded significantly highest (46.50) in the treatment T6 (Irrigation at branching and pod development stage: all furrows irrigated) which was at par with the treatment T4 (31.26). The lowest number of pods per plant was recorded where no irrigation was given i.e. T1 (18.63). Similar observations were recorded by Ramshe et al. (1987), Dixit et al. (1993) and Krishnamurthy and Steermanulu (2007).

Seed weight per plant (g)
The weight of seeds per plant was significantly influenced due to different treatment. The irrigation at branching and pod development stage all furrow irrigated recorded significantly highest seed weight per plant (9.21 g) which was at par with T6 (8.11). Irrigation at pod development stage: all furrow irrigated. These results are in accordance with Kamble (1989) [3], Sabale (1995) and Singh et al. (2006).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of pods plant(^{-1})</th>
<th>Weight of seed plant(^{-1}) (g)</th>
<th>Test weight (g)</th>
<th>Seed yield (q ha(^{-1}))</th>
<th>Stover yield (q ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>18.63</td>
<td>3.95</td>
<td>19.20</td>
<td>11.10</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>22.50</td>
<td>7.57</td>
<td>22.60</td>
<td>21.33</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>21.50</td>
<td>5.54</td>
<td>21.00</td>
<td>16.01</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>31.26</td>
<td>8.11</td>
<td>23.50</td>
<td>23.22</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>23.63</td>
<td>6.24</td>
<td>22.20</td>
<td>18.12</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>46.50</td>
<td>9.21</td>
<td>24.10</td>
<td>26.92</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>27.13</td>
<td>7.55</td>
<td>23.20</td>
<td>21.53</td>
</tr>
<tr>
<td>General Mean</td>
<td></td>
<td>27.31</td>
<td>6.88</td>
<td>22.26</td>
<td>19.75</td>
</tr>
</tbody>
</table>

S.E. +
<table>
<thead>
<tr>
<th>CD at 5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.33</td>
</tr>
</tbody>
</table>

CV %
| 11.92     |

Test weight (g)
The differences in the mean test weight as affected by different treatment were significant. The irrigation at branching and pod development (all furrows irrigated) recorded significantly higher test weight (24.10 g) i.e. T6 than other treatment but at par with irrigation at pod development stage (all furrows irrigated) (23.50 g) i.e. T4 and irrigation at branching and pod development stage (all furrows irrigated) (23.20 g) i.e. T7 treatment.

Seed yield (q ha\(^{-1}\))
The seed yield of chickpea due to T6 i.e. irrigation scheduling at branching and pod development stage (all furrows irrigated) recorded significantly more grain yield (26.92 q ha\(^{-1}\)) followed by T4 irrigation at pod development stage (all furrows irrigated) (23.22 q ha\(^{-1}\)). The lowest mean seed yield per hectare was recorded when no irrigation was applied (11.10 q ha\(^{-1}\)). Similarly, Ugale et al. (2000) Singh et al. (2006) and Krishmurthy and Steermanulu (2007) also observed the highest seed yield of chickpea when irrigated at flowering and pod formation stage.

Stover yield (q ha\(^{-1}\))
The yield of Stover was significantly affected due to irrigation scheduling treatment. Irrigation at branching pod development stage all furrows irrigated produced significantly higher Stover yield (31.80 q ha\(^{-1}\)) than rest of the treatments but it was at par with irrigation at pod development stage all furrows irrigated (29.96 q ha\(^{-1}\)).

Growth functions: Absolute photo-synthetically active radiation (APAR)
Photo synthetically active radiation (PAR) was computed using the linear relation obtained from line quantum sensor and digital lux meter. The PAR here recorded by keeping the sensor above the canopy and at ground surface within the crop. The sensor was kept in inverted position within and above the canopy for measured the reflected PAR. APAR was determined by using the formula given by Asrar et al. (1989).

\[
\text{APAR} = (\text{PAR}_0 + \text{RPAR}_s) - (\text{TPAR} + \text{RPAR}_c)
\]

Where,
\[
\text{APR}_0 = \text{Incident PAR above canopy}
\text{TPAR} = \text{Transmitted PAR from canopy}
\text{RPAR}_s = \text{Reflected PAR from soil}
\text{RPAR}_c = \text{Reflected PAR from canopy}
\]

Absorbed photo synthetically active radiation (APAR)
The amount of intercepted PAR not differed significantly among treatments during branching, flowering and maturity stage of chickpea. But at pod development stage the amount of intercepted PAR differed significantly among treatments. The treatment T6 i.e. irrigation at branching and pod development stage with all furrows irrigated intercepted significantly more PAR by 632.51 mJm\(^{-2}\) than rest of the irrigation treatments. Fully irrigated crop intercepted markedly more PAR over control (no irrigation). Similar
results were recorded by Brar et al. (2006) [2] and Singh et al. (2008) [6].

**Radiation utilization efficiency: Radiation use efficiency (RUE)**
Radiation use efficiency (RUE) is the dry matter production per unit of photo synthetically active radiation intercepted by the crop.

\[
RUE = \frac{\text{Total dry matter (g m}^{-2}\text{)}}{\text{APAR (MJ m}^{-2}\text{)}}
\]

APAR = Absolute photo synthetically active radiation.

There were significant differences in radiation utilization efficiency as influenced by different irrigation treatment at branching, flowering, pod development and maturity stages of chickpea. The irrigation treatment T6, *i.e.* irrigation at branching and pod development stage: all furrow irrigated produced significantly higher radiation use efficiency (g Ms\(^{-1}\)) 1.62, 1.45, 1.38 and 1.34 g Ms\(^{-1}\) at branching, flowering, pod development and maturity stages respectively than rest of the irrigation treatments. Similar observations were recorded by Singh et al. (2008) [6], Agrawal et al. (2001) and Rao et al. (1999) [4] that heat use efficiency increased successively from emergence to flowering phase of chickpea after vegetative stage was decreased successively. Radiation use efficiency obtained during vegetative phase was comparatively higher than at reproductive phase mainly due to higher heat use efficiency and crop growth rate.

**Table 8:** Absorbed photo synthetically active radiation as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Branching</th>
<th>Flowering</th>
<th>Pod development</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>17.39</td>
<td>300.82</td>
<td>528.69</td>
<td>742.86</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>16.37</td>
<td>350.82</td>
<td>620.40</td>
<td>873.34</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>15.33</td>
<td>321.35</td>
<td>590.37</td>
<td>833.41</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>15.58</td>
<td>333.79</td>
<td>619.68</td>
<td>877.93</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>15.34</td>
<td>290.08</td>
<td>596.35</td>
<td>854.14</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>14.82</td>
<td>334.02</td>
<td>632.51</td>
<td>890.66</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>15.44</td>
<td>309.38</td>
<td>628.69</td>
<td>793.45</td>
</tr>
</tbody>
</table>

General Mean | 0.67 | 17.16 | 11.18 | 33.16 |
S.E. + | N.S. | N.S. | 34.45 | N.S. |
CD at 5 % | 15.75 | 310.04 | 602.38 | 837.96 |
CV % | 7.40 | 9.28 | 4.21 | 6.85 |

The irrigation treatment T6, *i.e.* irrigation at branching and pod development stage: all furrow irrigated produced significantly higher radiation use efficiency (g Ms\(^{-1}\)) 1.62, 1.45, 1.38 and 1.34 g Ms\(^{-1}\) at branching, flowering, pod development and maturity stages than the rest of the treatments. Treatment T1, *i.e.* no irrigation produced significantly low radiation use efficiency at branching, flowering, pod development and maturity stage of chickpea. Similar observations were recorded by Singh et al. (2008) [6], Agrawal et al. (2001) and Rao et al. (1999) [4] that heat use efficiency increased successively from emergence to flowering phase of chickpea after vegetative stage was decreased successively.

**Table 9:** Radiation use efficiency of chickpea as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Branching</th>
<th>Flowering</th>
<th>Pod development</th>
<th>Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>1.42</td>
<td>1.31</td>
<td>1.27</td>
<td>1.21</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>1.48</td>
<td>1.34</td>
<td>1.31</td>
<td>1.24</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>1.46</td>
<td>1.32</td>
<td>1.27</td>
<td>1.22</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>1.52</td>
<td>1.39</td>
<td>1.34</td>
<td>1.28</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>1.48</td>
<td>1.32</td>
<td>1.28</td>
<td>1.22</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>1.62</td>
<td>1.45</td>
<td>1.38</td>
<td>1.34</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>1.49</td>
<td>1.38</td>
<td>1.32</td>
<td>1.27</td>
</tr>
</tbody>
</table>

General Mean | 1.50 | 1.36 | 1.31 | 1.25 |
S.E. + | 0.024 | 0.036 | 0.035 | 0.023 |
CD at 5 % | 0.076 | 0.11 | 0.11 | 0.069 |
CV % | 2.89 | 4.61 | 4.63 | 3.13 |

Radiation use efficiency obtained during vegetative phase was comparatively higher than at reproductive phase mainly due to higher heat use efficiency and crop growth rate.

**Quality parameters: Protein content in seed**
The mean protein content in seed was recorded as 23.09 per cent. The protein content in seed was not influenced by different irrigation treatment at different growth stages. The irrigation at branching and pod development stage all furrow irrigated recorded maximum protein content (23.80 %) in seed, than the rest of the treatments. The lowest mean protein content in seed was recorded when the chickpea was not irrigated (22.56 %) T1 (No irrigation). Similar observations were also found by Kulhare et al. (1988) and Pawar et al. (1992).
Table 10: Protein content in grain and protein yield as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Protein content in grain (%)</th>
<th>Protein yield (q ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>22.56</td>
<td>2.50</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>23.06</td>
<td>4.92</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>22.13</td>
<td>3.67</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>22.81</td>
<td>5.30</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>23.54</td>
<td>4.27</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>23.80</td>
<td>6.41</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>23.75</td>
<td>5.11</td>
</tr>
</tbody>
</table>

General Mean 23.09 3.48

S.E. + 0.51 0.18

CD at 5 % - 0.59

CV % 3.78 9.58

Protein yield per hectare
The mean protein yield of Digvijay chickpea was 3.48 q ha\(^{-1}\). The protein yield per hectare of Digvijay chickpea was influenced significantly due to different irrigation treatment. The protein yield was recorded significantly higher with irrigation at branching and pod development stage (6.41 q ha\(^{-1}\)) than rest of the treatment significantly lowest protein yield was recorded under no irrigation (control). These results are in accordance with Kamble (1989) [3], Pawar et al. (1992) and Kumar et al. (2000).

Economic studies
The mean total cost of cultivation (Rs ha\(^{-1}\)), gross monetary return (Rs ha\(^{-1}\)), net monetary return and benefit: cost ratio as influenced by various irrigation treatment was Rs 26350, 60844, 34494 ha\(^{-1}\) and 2.31, respectively. The irrigation at branching and pod development stage recorded highest total cost of cultivation, gross monetary return, net monetary return and benefit: cost ratio as Rs. 27250, 82558, 55308 ha\(^{-1}\) and 3.03, respectively than rest of the treatment.

Table 11: Cost of cultivation, gross monetary returns, net monetary returns and B:C ratio as influenced by different irrigation treatment

<table>
<thead>
<tr>
<th>S. No</th>
<th>Treatment</th>
<th>Cost of cultivation (Rs ha(^{-1}))</th>
<th>GMR (Rs ha(^{-1}))</th>
<th>NMR (Rs ha(^{-1}))</th>
<th>B:C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>No Irrigation</td>
<td>25650</td>
<td>34334</td>
<td>8684</td>
<td>1.34</td>
</tr>
<tr>
<td>T2</td>
<td>Irrigation at Branching: All furrows</td>
<td>26450</td>
<td>65768</td>
<td>39318</td>
<td>2.48</td>
</tr>
<tr>
<td>T3</td>
<td>Irrigation at Branching: Alternate furrows</td>
<td>26150</td>
<td>49567</td>
<td>23417</td>
<td>1.90</td>
</tr>
<tr>
<td>T4</td>
<td>Irrigation at Pod development stage: All furrows</td>
<td>26450</td>
<td>71448</td>
<td>44998</td>
<td>2.70</td>
</tr>
<tr>
<td>T5</td>
<td>Irrigation at Pod development stage: Alternate furrows</td>
<td>26150</td>
<td>55894</td>
<td>29744</td>
<td>2.14</td>
</tr>
<tr>
<td>T6</td>
<td>Irrigation at Branching and Pod development stage: All furrows</td>
<td>27250</td>
<td>82558</td>
<td>55308</td>
<td>3.03</td>
</tr>
<tr>
<td>T7</td>
<td>Irrigation at Branching and Pod development stage: Alternate furrows</td>
<td>26650</td>
<td>66341</td>
<td>39691</td>
<td>2.49</td>
</tr>
</tbody>
</table>

General mean 26350 60844 34494 2.30

Conclusion
Highest water use efficiency was observed when irrigation applied at pod development stage: all furrows irrigated (102.51 kg ha\(^{-1}\) cm). Highest water saving (%) was observed when irrigation applied at branching and pod development stage with alternate furrows irrigation (66.66). On the basis of results it could be concluded that cultivation of chickpea (cv. Digvijay) in rabi season, with irrigation scheduling at branching and pod development stage with all furrows irrigated is the best treatment to obtain better growth and yield among the other treatments studied.

References