GUIDE FOR

CHICKPEA (Cicer arietinum L.) PRODUCTION in the Southern Nations, Nationalities, and Peoples’ Region of Ethiopia
Producers (Consultants)
Million Eshete (Debre Zeit Agricultural Research Center)
Asnake Fikre (Ethiopian Institute of Agricultural Research)

Contributors

Hawassa University
Sheleme Beyene
Walelign Worku
Berhanu Abate
Endalkachew W/Meskel
Molla Assefa
Legesse Hidoto
Wondwosen Tena
Tussa Dedfo
Regassa Ayana

University of Saskatchewan
Bunyamin Tar’an
Fran Walley
Atul Nayyar (Editor)
# TABLE OF CONTENTS

1. INTRODUCTION ................................................... 1

2.0 PLANT DESCRIPTION ............................................. 4
   2.1 Roots .......................................................... 5
   2.2 Stems .......................................................... 5
   2.3 Leaves ........................................................ 6
   2.4 Flowers ....................................................... 6
   2.5 Pods and Seeds ............................................... 6

3.0 ADAPTATION ...................................................... 6
   3.1 Soil Type ...................................................... 6
   3.2 Temperature .................................................. 7
   3.3 Rainfall ........................................................ 7

4.0 VARIETY SELECTION ............................................ 7

5.0 CHICKPEA PRODUCTION ........................................ 10
   5.1 Site Selection ............................................... 10
   5.2 Land Preparation ........................................... 11
   5.3 Sowing Time and Methods .................................. 12
   5.4 Seeding Rate ................................................ 14
   5.5 Optimum Tillage Practices ................................. 14
   5.6 Weed Management ........................................... 14
   5.7 Fertilization ................................................ 15
   5.8 Harvesting ................................................... 16
   5.9 Threshing .................................................... 16

6.0 MAJOR DISEASES OF CHICKPEA ............................ 16
   6.1 Fusarium wilts \((Fusarium oxysporum\ f. \ sp. \ ciceri)\) ....... 17
   6.2 Collar rot \((Sclerotium rolfsii)\) ............................. 18
   6.3 Dry root rot \((Rhizoctonia bataticola)\) ..................... 18
   6.4 Fusarium root rot \((Fusarium solani)\) .................... 19

7.0 MAJOR FOLIAR DISEASES OF CHICKPEA ................... 19
   7.1 Ascochyta blight \((Ascochyta rabiei)\) ...................... 20
   7.2 Botrytis grey mold \((Botrytis cinerea)\) ................... 20
   7.3 Stunt Virus .................................................. 21

8.0 INSECT PESTS OF CHICKPEA ............................... 21
   8.1 Pod Borer \((Helicoverpa armigera)\) ....................... 22
   8.2 Adzuki Bean Beetle .......................................... 23

9.0 CHICKPEA RESEARCH DEVELOPMENT IN ETHIOPIA ....... 24

Bibliography .......................................................... 27
List of Tables

Table 1  Improved chickpea varities released by national and reginal program in Ethiopia .................................................. 9
Table 2  Grain yield (t/ha) as influenced by dates of planting at Halaba and Meskan districts .............................................. 13
Table 3  Grain yield (t/ha) as influenced by inoculation and P application ................................................................. 15
Table 4  Chickpea seed produced by chickpea producing organization (2011).............................................................. 26
List of Figures

Figure 1. Major chickpea growing regional states .......................... 2
Figure 2. Production area by wereda........................................... 3
Figure 3. Productivity potential wereda........................................ 3
Figure 4. Trend of chickpea area coverage and productivity during 1999/2000 -2011/............................................................. 4
Figure 5. Chickpea plant and its growth stages............................ 5
Figure 6. Distribution of area under chickpea production in Ethiopia (ha)................................................................. 8
Figure 7. Effects of land preparation method and sowing date on chickpea biomass weight and grain yield in Taba, southern Ethiopia ......11
Figure 8. Chickpea crop grown in drained seed bed ...................... 12
Figure 9. Symptoms of wilt caused by Fusarium oxysporum f. sp. ciceri .... 17
Figure 10. Symptoms of Collar rot caused by Sclerotium rolfsii .......... 18
Figure 11. Symptoms of dry root rot caused by Rhizoctonia bataticola . . . 19
Figure 12. Symptoms of ascochyta blight caused by Ascochyta rabiei .... 20
Figure 13. Symptoms of grey mold caused by Botrytis cinerea ............ 21
Figure 14. Cut worm: plant damaged by cutworm (left) and moth of cutworm (right) ................................................................. 23
Figure 15. Bruchids attack in chickpea seed under storage condition..... 23
1. INTRODUCTION

Chickpea is considered less labor-intensive crop and its production requires less external inputs as compared to cereals. Chickpea is widely grown around the world and serves as a multi-use crop. It plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. It can fix up to 140 kg N ha\(^{-1}\) from air and meet most of its nitrogen requirement. After harvest, it leaves substantial amount of residual nitrogen for subsequent crops and adds some amount of organic matter to maintain and improve soil health and fertility. This saves the fertilizer input cost not only for chickpea but also for the subsequent crops. Chickpea has the ability to grow on residual moisture which gives farmers the opportunity to engage in double cropping, where chickpea is sown at the end of the rainy season following the harvest of the main crop. This allows more intensive and productive use of land, particularly in areas where land is scarce. It is also an excellent source of protein, fiber, complex carbohydrates, vitamins, and minerals thus can help alleviating malnutrition and improving human health. The growing demand in both the domestic and export markets provides a source of cash for smallholder producers. Because of its deep tap root system, chickpea can withstand drought conditions by extracting water from deeper soil layers. It also increases livestock productivity as the residue is rich in digestible crude protein content compared to cereals.

Chickpea was first produced in the Middle East about 7,000 years ago. At present, it is produced in over 40 countries represented in all continents. However, the most important chickpea producing countries are India, Turkey, Pakistan, Iran, Mexico, Australia, Ethiopia, Myanmar, and Canada. Chickpea is currently grown on about 11 million hectares worldwide with 65% and 8% share belonging to India and Pakistan, respectively. Average annual production of chickpea is about 9 million tonnes with 95% of chickpea cultivation and consumption occurring in the developing countries.

The diverse agro-climatic conditions in Ethiopia make it very suitable for growing chickpeas. Chickpea is widely grown across
the highlands and semi-arid regions of Ethiopia and serves as a multi-purpose crop. The country is also considered as the secondary centre of diversity for chickpea (Anbessa and Bejiga, 2002). It has a major role in the daily diet of the rural community and parts of urban population. The crop is being exported to Asian countries and is contributing positively to the country’s foreign exchange earnings. Currently, chickpea is cultivated in four regions of the country, Amhara, Oromia, Southern Nations, Nationalities and People’s Region (SNNPR) and Tigray (Figure 1). Amhara and Oromia regions together produce 93% of total chickpea production in Ethiopia while SNNPR and Tigray produce 3.5% and 3%, respectively. The area coverage and the productivity of chickpea at district level are shown in figures 2 and 3. In future, chickpea can also be grown in other regions such as Benshngule, Somali, Afar and Harar. Thus, the area coverage and the importance of the crop in the country are expected to increase in the future.

Figure 1. Major chickpea growing regional states
Figure 2. Production area by wereda

Figure 3. Productivity potential wereda
Chickpea area coverage and productivity in Ethiopia have been increasing over a period of time (Figure 4). These clearly show the importance of the crop in the country as well as the utilization of improved technologies by the farming community. The last fifteen years data (1995 – 2010) obtained from the Central Statistics office show that chickpea production area, productivity and production in Ethiopia increased by 60, 100 and 200%, respectively (Figure 4).

![Production (blue) and Productivity (red) of chickpea](image)

**Figure 4.** Trend of chickpea area coverage and productivity during 1999/2000 -2011/2012

### 2.0 PLANT DESCRIPTION

Chickpea is an annual legume that stands erect and its height ranging from 30 to 70 cm. The plant produces primary, secondary and tertiary branching, resembling a small bush. The plants are naturally resistant to lodging and have the inflated pods. Each pod contains 1 to 2 seeds that are formed several inches above the ground and are relatively shatter resistant. The seeds of the plant remain below the ground during germination, offering the plant some tolerance to cool soil and ability to regrow if the top growth is damaged in the seedling stage (Figure 5)
2.1 Roots

The root system of chickpea plant is quite robust. It penetrates up to 2 m deep, although the major portions are found in the top 60 cm. Chickpea has a large tap root which allows the plant to access deeper water supplies.

2.2 Stems

Chickpea stems are branched, erect or spreading, sometimes shrubby. They can grow to a height of upto 1 m. The stems are glandular, hairy and have an olive, dark green or bluish-green colour.

Source: Saskatchewan Pulse Production Manual 2000

Figure 5. Chickpea plant and its growth stages

Source: Saskatchewan Pulse Production Manual 2000
2.3 Leaves

Some chickpea varieties have compound leaves with 8 to 20 leaflets, while some have simple leaves which are pubescent in appearance and have a top rachis (ending in a leaflet). Leaflets are ovate to elliptic in shape and their length ranges from 0.6 to 2.0 cm. The colour of the leaf is olive, dark green or bluish.

2.4 Flowers

Desi and Kabuli chickpea types can be easily identified by flower colour. The Desi varieties have purple/violet flowers while Kabuli types have white flowers. The flowers are solitary, sometimes 2 per inflorescence, auxiliary, pendulous 0.6 to 3 cm long, and with pedicles 0.5 to 1.3 cm long. Chickpea flowers are profuse and have an intermediate growth habit, continuing to flower and set pods as long as conditions are favourable.

2.5 Pods and Seeds

Pods set on chickpea plant occur on the primary and secondary branches, as well as on the main stem. Pods are short, pubescent and about 2 to 5 cm long and appear to be inflated. The individual round pods generally contain one seed in Kabuli types and often two seeds in Desi types. Kabuli chickpeas often have rounded and pale cream seeds, while Desi chickpeas are usually dark and angular shaped. Pods have a unique spherical shape with only a hint of a tail.

3.0 ADAPTATION

3.1 Soil Type

The plant requires fertile soil with good drainage system. Any waterlogged conditions can severely damage the crop. Chickpeas generally grow on heavy black or red soils and require a soil pH of 6.0 to 7.0. They prefer soil with good residual soil moisture content. Inoculating chickpeas with rhizobium, when planting first time in virgin sandy soils or in heavier soils can increase yield by 10-62%. In Ethiopia, chickpea is best adapted to the areas having Vertisols.
3.2 Temperature
Chickpea is a self-pollinated crop and usually grown as a rain-fed cool-weather crop or as a dry climate crop in semi-arid regions. The optimum daily temperature ranges from 18 to 29°C. Occurrence of frost and hailstones can severely damage the crop. Though sensitive to cold, some cultivars can tolerate temperatures as low as -9.5°C in early stages. A relative humidity of 21-41% is optimum for seed setting.

3.3 Rainfall
The plants grow well in areas with annual rainfall of between 600 - 1000 mm. However, chickpea productivity under marginal rainfall conditions may be increased through genotype selection and manipulation of planting density. Owing to its deep tap root, chickpea is fairly drought tolerant as it is able to extract moisture from deep layers of soil profile, but its productivity is reduced by the recurrence of the terminal droughts.

4.0 VARIETY SELECTION
There are two different types of chickpea that are grown worldwide- Desi and Kabuli.

Desi
Desi chickpeas have colored and thick seed coat. The seed colors of Desi chickpeas are brown, yellow, green or black. The seeds are generally small and angular with a rough surface. The flowers are generally pink and the plants show various degrees of anthocyanin pigmentation, although some Desi types have white flowers and no anthocyanin pigmentation on the stem. The Desi types account for 80-85% of world’s chickpea area. The splits (dal) and flour (besan) are invariably made from desi type.

Kabuli
The Kabuli type chickpeas are characterized by white or beige-colored seed with ram-head to rounded shape. The seed coat is thin with smooth seed surface. The flowers of Kabuli type are white and
lack anthocyanin pigmentation on the stem. As compared to Desi type, the Kabuli type has higher levels of sucrose and lower levels of fiber. The Kabuli type generally has large seed size and receive higher market price than Desi type. The price premium in Kabuli type generally increases as the seed size increases. Among the two chickpea types, the Desi type is dominantly grown in Ethiopia. The major chickpea growing zones include: East Shewa, West Shewa and North Gonder (Figure 6).

![Figure 6. Distribution of area under chickpea production in Ethiopia (ha)](image)

There are many agronomic and market factors to consider when choosing a variety.

Yield is an obvious consideration within a market class. However, other characteristics such as disease tolerance, maturity or harvestability can quickly overshadow potential yield gains, if the plant is limited in reaching its full potential.

Disease resistance, specifically resistances to ascochyta blight, wilts and root rot, are important factor in variety selection. Ascochyta blight easily overcomes the typical chickpea disease defense
mechanisms. As a result, complete resistance to blight has not been identified in chickpea. Resistance is most pronounced in young plants which become more susceptible to disease attack as they age (Jayakumar et al., 2005). Partial resistance to ascochyta alone may not provide sufficient disease control (Chongo and Gossen, 2001).

In Ethiopia, the national chickpea improvement program (Debre Zeit Agricultural Research Center) has released seventeen improved chickpea varieties from landraces and distributed to farmers (Table 1). Additional five improved varieties have also been released by the regional research centers, Srinka and Debre Brhan. The improved varieties released by the national research program are highly productive and have larger seeds as compared to local variety.

Table 1. Improved chickpea varieties released by the national and regional programs in Ethiopia

<table>
<thead>
<tr>
<th>Variety</th>
<th>Center released the variety</th>
<th>Year of release</th>
<th>Days to Mat.</th>
<th>100 seed wt (g)</th>
<th>Seed rate (kg/ha)</th>
<th>Altitude (m.a.s.l.)</th>
<th>Rainfall (mm)</th>
<th>Productivity (Q/ha)</th>
<th>Research station</th>
<th>Farmers field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dubie</td>
<td>Debre Zeit</td>
<td>1978</td>
<td>110-115</td>
<td>22.0</td>
<td>80-90</td>
<td>1800 – 2300</td>
<td>700 - 1100</td>
<td>17.28</td>
<td>16-17</td>
<td></td>
</tr>
<tr>
<td>Mariye</td>
<td>Debre Zeit</td>
<td>1985</td>
<td>106-120</td>
<td>25.5</td>
<td>120-140</td>
<td>1500 – 2300</td>
<td>700 - 1300</td>
<td>18-30</td>
<td>14-23</td>
<td></td>
</tr>
<tr>
<td>Worku</td>
<td>Debre Zeit</td>
<td>1994</td>
<td>100-149</td>
<td>33.0</td>
<td>100-120</td>
<td>1900 – 2600</td>
<td>700 - 1200</td>
<td>19.40</td>
<td>19-29</td>
<td></td>
</tr>
<tr>
<td>Akaki</td>
<td>Debre Zeit</td>
<td>1995</td>
<td>57-147</td>
<td>21.0</td>
<td>90-120</td>
<td>1900 – 2600</td>
<td>700 - 1200</td>
<td>18-42</td>
<td>14-26</td>
<td></td>
</tr>
<tr>
<td>Aranie</td>
<td>Debre Zeit</td>
<td>1999</td>
<td>105-155</td>
<td>25.7</td>
<td>100-115</td>
<td>1900 – 2600</td>
<td>700 – 1200</td>
<td>26-46</td>
<td>20-32</td>
<td></td>
</tr>
<tr>
<td>Shasho</td>
<td>Debre Zeit</td>
<td>1999</td>
<td>90-155</td>
<td>29.9</td>
<td>100-125</td>
<td>1800 – 2600</td>
<td>700 - 1200</td>
<td>26-52</td>
<td>18-22</td>
<td></td>
</tr>
<tr>
<td>Tje</td>
<td>Debre Zeit</td>
<td>2005</td>
<td>122-130</td>
<td>32</td>
<td>120-140</td>
<td>1800-2700</td>
<td>700-1200</td>
<td>20-35</td>
<td>16-29</td>
<td></td>
</tr>
<tr>
<td>Natoli</td>
<td>Debre Zeit</td>
<td>2007</td>
<td>136</td>
<td>22</td>
<td>120-130</td>
<td>1800-2700</td>
<td>700-1200</td>
<td>22-26</td>
<td>20-25</td>
<td></td>
</tr>
<tr>
<td>Acos Dubie</td>
<td>Debre Zeit</td>
<td>2008</td>
<td>136</td>
<td>64</td>
<td>140-160</td>
<td>1600-2400</td>
<td>600-1200</td>
<td>11-24</td>
<td>10-13</td>
<td></td>
</tr>
<tr>
<td>Minjar</td>
<td>Debre Zeit</td>
<td>2010</td>
<td>86-143</td>
<td>28</td>
<td>120-140</td>
<td>1800 – 2600</td>
<td>700 – 1200</td>
<td>22-50</td>
<td>20-40</td>
<td></td>
</tr>
<tr>
<td>Mastewal</td>
<td>Debre Brhan</td>
<td>2006</td>
<td>105-139</td>
<td>-</td>
<td>100-115</td>
<td>700-1000</td>
<td>700-1000</td>
<td>25-33</td>
<td>15-19</td>
<td></td>
</tr>
<tr>
<td>Yelebe</td>
<td>Srinka</td>
<td>2006</td>
<td>77-106</td>
<td>-</td>
<td>120-130</td>
<td>660-1025</td>
<td>660-1025</td>
<td>18.2</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Kasech</td>
<td>Srinka</td>
<td>2011</td>
<td>100</td>
<td>-</td>
<td>130-150</td>
<td>660-1025</td>
<td>660-1025</td>
<td>20-25</td>
<td>16-20</td>
<td></td>
</tr>
<tr>
<td>Akuri</td>
<td>Srinka</td>
<td>2011</td>
<td>98</td>
<td>-</td>
<td>130-150</td>
<td>660-1025</td>
<td>660-1025</td>
<td>21-26</td>
<td>17-20</td>
<td></td>
</tr>
</tbody>
</table>
Fifteen genotypes including Desi (4 varieties), Kabuli (5 varieties) and introduced materials (6 Kabuli types) were evaluated in zinc deficient soils in Jolle andegna (Gurage), Taba (Wolayita) and Huletegna choroko (Halaba). Based on the result across location, the highest grain yield was obtained from variety Natoli followed by Butajira local and Arerti. The variety Arerti was also found to be highest in seed zinc concentration. Its Zn concentration was equal to that of FLIP07-27C and FLIP08-60C. The variety FLIP08-60C also had highest seed Fe concentration followed by the FLIP03-53C and Arerti.

Results of 2012 trials showed statistically significant yield differences among the genotypes. Variety Mastewal gave the highest grain yield at Halaba and Butajira, while variety Natoli was best at Taba. During the 2013 trial, varieties Mastewal and Natoli maintained their good performances at Halaba and Butajira.

5.0 CHICKPEA PRODUCTION

5.1 Site Selection

It is important to know the history of the land before selecting the site for chickpea cultivation. For example, a stony land could be a great challenge during cultivation and land where excess water accumulates during the rainy season is not recommended for chickpea production. Planting chickpea in waterlogged soil leads to rotting of seeds and also exposes the seeds to damping off fungal diseases. Heavily waterlogged soil considerably reduces the root volume, number of nodules and the plant growth of chickpea. As a result, water uptake, nutrient uptake, nitrogen fixation process and finally the productivity of the crop will be adversely affected. Thus, land for chickpea cultivation needs to be free from water logging problem throughout the growth stage of the crop. If the land is sloppy, soil conservation measures have to be taken to minimize the runoff of the soil. Likewise, the use of various drainage practices such as broad bed and furrow and ridge and furrow is also important for lands where excess water accumulates during the rainy season and create serious waterlogging problems.
5.2 Land Preparation

Chickpeas are poor competitors with weeds. It is important to eradicate as much weeds as possible from the soil. It is therefore, advisable to plough the soil deep once from March to May in dry season and disk twice from Mid-June to early August. This will expose the weeds and finally kill them. In addition, the soil will be aerable and more conducive for chickpea cultivation. Where chickpea is grown on flat heavy clay soils, it is advisable to use ridge and furrow (RF) plots as it facilitate the removal of excess water from the field. Broad bed and furrow (BBF) can also be used on gentle slopes of 0-0.8% to get well established crop.

A study on land management practices and sowing time conducted at Taba, southern Ethiopia showed that cultivating chickpeas on broad bed and furrow (BBF) increased grain yield of chickpeas on Vertisols over other land preparation methods (Figure 7). Early planting also enabled the plant to have longer vegetative and grain filling time resulting in higher yield. Thus, it can be recommended that the use of BBF (Figure 8) combined with sowing in mid-August is useful practice that can be adapted by farmers of this region.

**Figure 7.** Effects of land preparation method and sowing date on chickpea biomass weight and grain yield in Taba, southern Ethiopia.
Numerous herbicides are available in the market that can control weed, which are competing with chickpea. However, before using these herbicides, it is important to know the field’s weed history and herbicide resistant weeds. If certain weeds are present in high numbers and cannot be controlled, a different field should be selected for chickpea cultivation.

Figure 8. Chickpea crop grown in drained seed bed

5.3 Sowing Time and Methods

Planting time is an important factor in increasing chickpea yield. The recommended sowing times for chickpea vary with altitudes, locations, and depends upon site specific seasonal rain fall, soil type and maturity period of specific chickpea variety. The recommended sowing date for Vertisols of medium and high altitude areas is from mid August to early September depending upon the intensity of rainfall. Advancing planting time to mid August increase about 50% yield in chickpea since planting during this rainy season allows the crop to grow vigorously and enable it to make efficient use of conserved moisture during germination, establishment and seed filling stage. In low moisture stressed environments such as low lands or sandy soils, early planting in July is advantageous. Chickpea can be sown in rows or broadcasted. Planting in row gave higher yields as compared with broadcast method as the former facilitates inter-row cultivation and weed management practices.
Determinations of appropriate planting date revealed that early sowing resulted in significantly higher growth and yields of chickpea at Halaba, whereas only plant height and grain yield were improved at Meskan. In Halaba, the varieties planted at the second sowing date (August 20\textsuperscript{th}) gave highest grain yields (3.8 t/ha), followed by the third (August 27\textsuperscript{th}) and first (August 13\textsuperscript{th}) planting dates with grain yields of 3.0 and 3.2 t ha\textsuperscript{-1}, respectively. From the two varieties, Mastewal was better in grain yield (3.1 t/ha) than variety Habru (2.8 t/ha). In Meskan district, the variety Habru planted on 13th September produced the highest grain yield of 2.5 t ha\textsuperscript{-1} compared to the lowest yield of 1.5 t ha\textsuperscript{-1} harvested from the last (4\textsuperscript{th} October) sowing date. The study showed that planting chickpea in Halaba in early August was more productive than late planting, while in Meskan sowing chickpea from late August to September enhanced grain yield. Sowing date of chickpea, therefore, varied from location to location depending on soil moisture and duration of the rainy season (Table 2).

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Grain yield (t/ha) as influenced by dates of planting at Halaba and Meskan districts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Halaba</td>
</tr>
<tr>
<td>Sowing date</td>
<td>Grain yield t/ha</td>
</tr>
<tr>
<td>13/8/2014</td>
<td>3.2</td>
</tr>
<tr>
<td>20/8/2014</td>
<td>3.8</td>
</tr>
<tr>
<td>27/8/2014</td>
<td>3.0</td>
</tr>
<tr>
<td>3/9/2014</td>
<td>2.8</td>
</tr>
<tr>
<td>10/9/2014</td>
<td>2.5</td>
</tr>
<tr>
<td>17/9/2014</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Variety</td>
<td></td>
</tr>
<tr>
<td>Habru</td>
<td>2.8</td>
</tr>
<tr>
<td>Mastewal</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Six nationally released varieties (Habru, Mastewal, Natoli, Arerti, Shasho and Ejere) and one local variety were used to evaluate the influence of preceding crop on chickpea performance on farmers’ fields at Halaba. The performances of all varieties including the local were higher under “maize-chickpea” than “haricot bean-chickpea” double cropping, which was attributed to higher pest incidence when chickpea followed haricot bean. Thus, growing chickpea as double cropping after cereal crop is more advantageous in terms of yield and cost of production.

5.4 Seeding Rate

The optimum planting density for chickpea varies with location, the growing conditions and growth habit of the variety. In some cases, seeding rate has no significant effects on seed yield due to the capacity of the crop to produce large number of branches to compensate for low plant population. However, it is essential to use high seed rate in ensuring good plant stand under adverse environmental conditions. For row planting, a spacing of 30 cm between rows and 10 cm between plants is recommended (i.e. a density of about 333,334 plants/ha). A reduced spacing between plants can be used for varieties that are more erect and hence plant density can be increased. However, seed rate by broadcast application method appears to vary depending up on the seed size of the cultivars and growth habit. High seed rates for large seeded and low seed rates for varieties with small seed size are recommended.

5.5 Optimum Tillage Practices

Studies conducted at Akaki and Debre Zeit to assess the response of chickpea to tillage and weed control practices indicated that first plowing at mid April before planting with weeding gave a higher seed yield. This can be followed by second plowing at mid April to late June before planting.

5.6 Weed Management

Chickpea is a poor competitor with weeds at all stages of growth. Pre-emergence herbicides, such as Fluchloralin @ 1 kg a.i. ha$^{-1}$ or Pendimethalin @ 1.0 to 1.5 kg a.i. ha$^{-1}$ were found effective in con-
trolling early flush of weeds. Mechanical and/or manual weeding can also be done where wide row spacing is used.

5.7 Fertilization

From different fertilizer trials conducted around Debre Zeit, it was confirmed that neither fertilizer rates nor sources have a marked effect on yield of chickpea on Vertisols. Significant influence of NP fertilizers on growth and yield of chickpea was also not obtained from the experiments conducted in Meskan, Sodo and Damot Gale woredas during the 2013 cropping season. Furthermore, experiments on growth and yield response of chickpea to seed inoculation with rhizobium and NP fertilizer application at Halaba, Damot Gale, Meskan and Sodo districts showed no significant difference in grain yield between seed inoculation with Cp41 strain alone and inoculated seed plus 60 kg DAP fertilizer application. However, highest grain yields of chickpea were harvested from the inoculated seed with Cp41 rhizobium strain and the inoculated seed with 60 kg DAP fertilizer per hectare across locations. In addition, chickpea straw and grain yields were enhanced by inoculating seeds with Cp41 rhizobium strain and application of 12 kg P ha$^{-1}$. Thus, inoculation of *Mesorhizobium* strain Cp41 along with 12 kg ha$^{-1}$ P application can serve as a potential option to improve the grain yield and total biomass of chickpea (Table 3). Therefore, there are advantages to be gained successfully through inoculation with efficient inoculant like Cp 41 with or without 60 kg DAP ha$^{-1}$ under existing environments.

<table>
<thead>
<tr>
<th>Treatment/location</th>
<th>Variety Habru</th>
<th></th>
<th>Variety Arerti</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Choroko-</td>
<td></td>
<td>Jole-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Taba</td>
<td></td>
<td>2 Gogeti</td>
</tr>
<tr>
<td>0</td>
<td>1.2</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>60kg DAP/ha</td>
<td>1.8</td>
<td>2.1</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>CP41 inoculant</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>CP41 + 60kg DAP</td>
<td>2.6</td>
<td>2.5</td>
<td>3.0</td>
<td>2.2</td>
</tr>
</tbody>
</table>
5.8 Harvesting

The time of harvesting is crucial in maintaining the quality of seeds. The crop should be harvested when leaves start to senesce and start shedding. The pods on the plant will turn yellow and seeds in the pods feel hard and rattle within the pod. After harvest, the plants can be dried in the sun for a few days to ensure that seeds get dry enough. Depending on the varieties, chickpea matures usually within 95 - 140 days after emergence and is manifested by light green coloration of pods. It is advisable to harvest when about 90-95% of the crop matures. Chickpea harvesting in Ethiopia is done by hand and the use of combine harvester has not yet been practiced in the country.

5.9 Threshing

Threshing is usually done by driving animals on the plants on well-prepared threshing ground or by threshers. When threshing is done by driving animals, cemented ground is advised for maintaining the quality of the crop; however, threshing the large Kabuli seeds by driving animals could result in broken seeds thus reducing their quality, market value and germination.

6.0 MAJOR DISEASES OF CHICKPEA

Chickpea is prone to damage by many diseases and insect-pests. In general, root diseases (fusarium wilt, collar rot and dry root rot) and foliar diseases (ascochyta blight, botrytis grey mold) are important diseases in Ethiopia. Among the insect pests, infestation by pod borer (Helicoverpa armigera) is the most severe. The insect infestation is severe throughout the country and has been reported to significantly reduce the crop yield. Cutworm is next to pod borer in affecting chickpea. It is more common in the northern part of the country. Bruchids (Callosobruchus chinesis) is yet another insect that damages the seeds during storage. Timely preventative measures should be taken to prevent chickpea from insect or pest attack and to maximize the yield.
6.1 Fusarium wilts (*Fusarium oxysporum* f. sp. *ciceri*)

Fusarium wilt is the most important disease-affecting chickpea yield in Ethiopia. The fungus infects chickpeas via the roots system and moves throughout the plant’s vascular system. The cell wall starts degrading by the enzymes produced by the pathogen. The pathogen then forms the gels that block the plant’s transport systems and cause yellowing and wilting of the plant. Vascular discolouration occurs on the roots and then towards the young stems, followed by yellowing and wilting of the leaves before final necrosis. The seedlings that are affected with fusarium, first show dropping of the leaves and then finally collapse (Figure 9). The roots look healthy but when split vertically the vascular tissues show brown to black discoloration. The fungus is seed and soil borne and can survive in the soil even in the absence of the host.

**Control measures:** Fusarium resistant varieties (eg, Arerti, Habru) should be planted in the areas that are affected with fusarium wilt. Deep plowing during short rain season (March to April) and removal of host debris from the field can reduce the level of inocula. Excluding chickpea from the crop rotations in infested fields for at least 3 years and seed treatment with *Trichoderma viride* @ 4 g kg\(^{-1}\) seed has been found effective in reducing incidence of wilt.

![Figure 9. Symptoms of wilt caused by *Fusarium oxysporum* f. sp. *ciceri*](image_url)
6.2 Collar rot (*Sclerotium rolfsii*)

The disease is usually observed under wet warm conditions. The first visible symptoms appear as yellowing or wilting of the lower leaves which progresses towards the upper ones (Figure 10). The collar region of the chickpea plant is constricted and begins to rot. White mycelia strands with minute mustard seed-sized sclerotial bodies are seen growing over the affected tissue. The affected seedlings turn yellow and wilt.

**Control measures:** The only economic control consists of long term rotations with non-susceptible host, deep plowing and removing undecomposed debris from the field before sowing.

![Figure 10. Symptoms of Collar rot caused by *Sclerotium rolfsii*](image)

6.3 Dry root rot (*Rhizoctonia bataticola*)

It is a serious disease under moisture stress conditions and when the crop is exposed to temperature above 30°C. The disease generally appears around flowering and podding stage. Dropping of petioles and leaflets occurs and is confined to top of the plant. Sometimes, when the rest of the plant is dry, the top most leaves are chlorotic. The whole plant finally dries up and turns straw-colored (Figure 11). Roots become black and brittle and have only a few or no lateral roots.
Control measures: Apply crop rotation with cereals. A longer crop rotation of at least 3 years is recommended after harvest of chickpea. Seed treatment with fungicides can reduce initial development of the disease. Timely sowing of chickpea should be done to avoid post-flowering drought and heat stresses, which aggravate the disease.

6.4 Fusarium root rot (*Fusarium solani*)

The disease is favored by a temperature between 22 and 28°C and high soil moisture. The disease can appear at any growth stage of the crop. It causes yellowing of the basal foliage, stunted growth and reddening of the vascular tissue below the soil line.

Control measures: Since the level of resistance in chickpea to Fusarium root rot is not high, an integrated approach that includes cultural practices (drainage), maintenance of good seed vigor and genetic resistance is required.

7.0 MAJOR FOLIAR DISEASES OF CHICKPEA

Historically, chickpea production has not been threatened by foliar disease in Ethiopia. However, due to changes in chickpea production, germplasm exchanges and changes in rainfall pattern, foliar diseases (ascochyta blight, grey mold and stunt virus) are becoming a problem in Ethiopia.
7.1 Ascochyta blight (*Ascochyta rabiei*)

Ascochyta blight is a devastating disease when cool and wet weather condition prevails. The pathogen is seed and stubble borne. In Ethiopia, it is an important disease in early-planted chickpeas in the lowlands and when rainfall extends beyond September.

**Symptoms:** Symptoms of the disease usually appear around flowering and podding time. The plants are destroyed and appear as patches of blighted plants in the field. Typical circular spots appear on leaves and pods, elongated lesions on stem, and deep cankerous lesions on seeds (Figure 12).

**Control measures:** Ascochyta blight can be controlled through the use of resistant cultivars, such as Arerti, Habru and Ejere. However, other practices such as the use of pathogen free seeds, seed treatment with fungicides, foliar fungicide spray, stubble management and crop rotations can augment disease resistance.

![Figure 12 Symptoms of ascochyta blight caused by *Ascochyta rabiei*](image)

7.2 Botrytis grey mold (*Botrytis cinerea*)

It is one of the foliar diseases of chickpea in Ethiopia. Affected leaves become yellow followed by defoliation. Water soaked lesions and rotting of terminal buds with moldy growth are the main foliage symptoms (Figure 13). The disease can cause flower drop resulting in poor pod setting, and extension of the crop duration.
Control measures: Use of resistant varieties is the best control measure. Additionally, thinning out an infected crop to allow more light to penetrate the canopy; intercropping with a crop such as linseed, which is resistant to the pathogen; and foliar sprays of captan, carbendazim, chlorothalonil or mancozeb at regular intervals (2-3 times) starting at first appearance of the disease can control an epidemic and further spread of the disease.

Figure 13. Symptoms of grey mold caused by Botrytis cinerea

7.3 Stunt Virus
Stunt virus is an important group of virus that affects legumes grown in cool season and causes yellowing, chlorosis, reddening and stunting of the plant. The viruses that are involved in various legume are Bean Leaf roll Luteovirus, beet western yellows virus, soybean dwarf virus and chickpea Luteovirus. They are transmitted by aphids like Aphis craccivora and Acrythosiphon pisum.

Control measures: Cultural practices such as varying sowing dates, plant density and using borders plants which are not hosts to the virus are effective in reducing yield losses.

8.0 INSECT PESTS OF CHICKPEA
Chickpea is an important crop grown in different parts of the country. Despite its wide cultivation, it is attacked by a various insect pests. Most common pests that attack chickpea in field are African Bollworm (Helicoverpa armigera) and cut worm (Agrotis segetum), whereas
most common pest that affect chickpea in store is Adzuki bean beetle (*Callosobruchus chinensis*) which is also sporadic in its status.

### 8.1 Pod Borer (*Helicoverpa armigera*)

It is the most important pest of chickpea in all the chickpea growing areas. It damages almost all the pods in case of severe damage, but causes nearly 20-30% annual yield losses in Ethiopia. The eggs (1 mm diameter) are laid singly on the leaflets, flowers, immature pods and stems. Larvae can be green, brown, yellow, or pink, but are usually striped, irrespective of their color. Larvae feed on leaves during the vegetative phase and on flowers and pods during the reproductive phase. The third- to fifth-instar larvae feed on the developing seed after making a hole in the pods.

**Control measures**: Varieties with high levels of resistance to pod borer are not available, though accession ICCV-7 was found relatively tolerant to the pest. Though pod borer can be effectively controlled through application of insecticides at the first and second stage{e.g. Cypermethrin (45g ai/ha) and Endosulfan (472 g ai/ha)}, an integrated pest management (IPM) strategy is recommended as it is eco-friendly, does not eliminate natural enemies of pod borer, reduces pesticide residues, and the risk of development of resistance to insecticides.

**Population monitoring**: Monitoring of *H. armigera* population in the field is a prerequisite for successful plant protection. Sex pheromone traps are used to monitor the pest population build-up. Pheromones are specific to individual species. These traps are of different shapes or colors and can be placed at different heights depending upon insect activity and crop architecture. In chickpea, these are placed at 1 m height from the ground level immediately after sowing. The pheromone traps are not useful in controlling the pest directly, but provide an estimate of the pest population, and are an effective tool for timely use of control measures. Visual observations should regularly be made on the larval population in the field. The action threshold is 1-2 larvae (2\textsuperscript{nd} to 3\textsuperscript{rd} instars) per meter row. To count the larvae, one should observe 10 plants at random at five locations.
diagonally across the field, and calculate mean larval density to decide on use of control measures to be adopted.

**Cutworm (Agrotis ipsilon)**

This is generally a pest of minor importance, but may reduce plant stand in case of severe infestation. Gray-black larvae hide beneath the soil surface during the day, and become active at night. They cut the seedlings at or below ground level (Figure 14).

**Control measures:** Most broad-spectrum insecticides are effective in controlling cutworm.

![Figure 14. Cut worm: plant damaged by cutworm (left) and moth of cutworm (right).](image)

**8.2 Adzuki Bean Beetle**

The beetle causes substantial weight loss under farmers’ storage conditions (Figure 15). A loss assessment study using improved variety revealed a mean weight loss of 52% within eight months of storage period.

![Figure 15. Bruchids attack in chickpea seed under storage condition](image)
Control measures

Chemical: Different insecticides were screened and Actellic 2% dust at the rate of 50 g/100kg was found effective in controlling this storage pest. However, recent studies showed that the insecticide is less effective and frequent applications are required.

Botanicals: Several plants species were evaluated and efficacious plant was found. Birbira *Melletia feruginea* at 5% w/w gave complete protection of chickpea for long period. Nonetheless, the toxicity of this species to human being has not yet been investigated.

9.0 CHICKPEA RESEARCH DEVELOPMENT IN ETHIOPIA

In current scenario chickpea variety, seed supply and availability, mechanization, processing, market and management practice are factors which need major attention in promoting the current chickpea research and development.

Variety: In chickpea research and development program, the supply of varieties is one of the most important components to meet the varying interests and changing demand of the ultimate users. In this regard, the national research system is expected to make continuous efforts in evaluating the landraces, exotic germplasm and finished technologies and continuously develop varieties, which are adapted to the different chickpea growing agro ecologies of the country. In addition, the research system needs to work its best to bring into picture the so far released chickpea varieties to contribute their part in the countries development program. The research system also needs to work hand in hand with extension system to popularize and scale up the varieties, especially those which have high demand in overseas market. Developing varieties that are adaptive to moisture stress environments and expanding the varieties in the areas are important tasks, which need to be worked out immediately, as well.

On the basis of the 2010 Central Statistics Authority data, coverage of improved chickpea technology in the country is 25% which is also expanding fast from time to time. The remaining 75% chickpea area is covered by the desi type chickpeas which has got high diversity in
the country. The pre-scaling works of the Debre Zeit Agricultural re-
search center that have been undertaken in some selected districts
of chickpea growing areas have also shown outstanding results in
expanding the improved chickpea varieties in the areas. Hwassa
University through its collaborative project with University of Sas-
katchewan “Promoting Adoption of Chickpea Technology in South-
ern Ethiopia” has also conducted pre-scaling work that showed the
preformances of improved varieties differing under different growth
conditions.

**Seed supply and availability.** Seed is an important component that
should be given emphasis and strong support in chickpea research
and development relations. The formal seed sector contributes
7-10% of the chickpea seeds demand in the country and the
Ethiopian Seed Enterprise is the main contributor of chickpea seed
for the sector. Thus, formal seed sector need to be given the first
priority.

In the informal seed sector, seed producing organization, individual
farmers, farmer’s research group and seed producing organization
under unions are the main sources of seed. A total of eight chickpea
seed producing organizations have been established in the country
in the past seven years, since 2007. These organization reached a
production management stage that answer the demand of chickpea
seed in the country(Table 4). The seed production exercise followed
by this organization is complicated and their capacity is also limited.
Thus, great efforts need to be made to strengthen the capacity of
these organizations.

**Mechanization.** Improved agricultural equipment is one of the
inputs, which help to improve the productivity and quality of
chickpea and hence have high demand by producers. It is important
that farm equipments used for land preparation, planting and
trashing need to be improved and supplied to farmers with
reasonable/affordable prices. Thus, to fill the gap in the area, all
stakeholders have to give emphasis for team work. The sectors like
agricultural technology and mechanizations need to work together
in developing and expanding the implementation initial stage of the
work.
Table 4  Chickpea seed produced by chickpea producing organization (2011)

<table>
<thead>
<tr>
<th>Seed producing organization</th>
<th>Variety</th>
<th>Participating farmers</th>
<th>Area (ha)</th>
<th>Production (ton) farmers own seed source</th>
<th>Production (ton) farmers</th>
<th>Total production (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemlem Chefe</td>
<td>Arerti,Natoli,Teji</td>
<td>28</td>
<td>7</td>
<td>25</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>Hawi Boru</td>
<td>Arerti,Natoli,Teji</td>
<td>28</td>
<td>7</td>
<td>25</td>
<td>380</td>
<td>405</td>
</tr>
<tr>
<td>Bifetu</td>
<td>Arerti,Habru,Shasho</td>
<td>64</td>
<td>16</td>
<td>64</td>
<td>670</td>
<td>734</td>
</tr>
<tr>
<td>Chala</td>
<td>Arerti,Habru,Shasho</td>
<td>64</td>
<td>16</td>
<td>66</td>
<td>650</td>
<td>716</td>
</tr>
<tr>
<td>Megertu</td>
<td>Arerti,Habru,Natoli</td>
<td>95</td>
<td>24</td>
<td>96</td>
<td>980</td>
<td>1076</td>
</tr>
<tr>
<td>Ude</td>
<td>Arerti,Natoli,Teji</td>
<td>48</td>
<td>12</td>
<td>48</td>
<td>895</td>
<td>943</td>
</tr>
<tr>
<td>Mehere Agre</td>
<td>Arerti</td>
<td>44</td>
<td>11</td>
<td>44</td>
<td>240</td>
<td>284</td>
</tr>
<tr>
<td>Hundufa Hatau</td>
<td>Arerti,Natoli,Teji</td>
<td>154</td>
<td>35</td>
<td>120</td>
<td>320</td>
<td>440</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>525</td>
<td>128</td>
<td>488</td>
<td>4585</td>
<td>5073</td>
</tr>
</tbody>
</table>

**Agro processing.** Agro processing industries using chickpea as inputs are few in numbers. In addition, no works so far have been done in food science area of chickpea. As chickpea production and quality of product are getting improved, different ways of food preparation methods need to be develop to get the best out of it. Institutions associated with this also need to make efforts to solve the agro processing related problems in chickpea, as gap in the area is wide in Ethiopia.

**Methods of production.** Depending upon the growing environments and the farmers’ experiences, different methods of chickpea production are used. About 85% of chickpea in Ethiopia is grown as rainfed crop, sole or double cropped or in rotation with other cereals. Growing chickpea under irrigated condition (in rotation with cotton, vegetables, and cereals) is also getting importance in areas where the irrigation infrastructure exists. Traditionally chickpea is grown in residual moisture. The crop is often exposed to moisture stress and this in turn results in 20-40% yield reduction, although this practice is claimed to minimize the incidence of insect pests, weed and disease. Thus, the production methods to be followed depend on the advantage gained by the producer.
Bibliography


