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Haricot Bean Production Guide

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1. BASIC FACTS

1.1 General

Haricot bean is an important pulse crop in Ethiopia and in the world. The crop ranks first globally while it stands second next to faba bean in the country. The major haricot bean producing regions include Oromia, Amhara and Southern Nations Nationalities and Peoples Region (SNNPR). Their share to the national haricot bean production is 51% for Oromia, 24% for Amhara and 21% for SNNPR (Fig. 1). Haricot bean is the most important pulse crop in the SNNPR. It is grown both as sole crop and in association with other crops. Though it is produced in most parts of the southern region, the leading zones of production are Sidama, Wolayita and Gamo Gofa (Fig. 2).

Fig. 1: Haricot bean production areas in Ethiopia

The nutritional composition of haricot bean contributes greatly towards a balanced and healthy diet. This is because the grain has high protein content and good micro-nutrient concentration (Table 1). As some people say it is considered as 'a poor man’s meat' because of its high protein content. Moreover, their amino acid composition is useful to complement the amino acid profile of cereal proteins. Thus, haricot bean is an important crop in addressing the issue of nutrition security in southern Ethiopia where people’s diet is dominated with maize, root and tuber crops.

**Table 1: Nutritional composition of haricot bean and maize grain**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Haricot bean*</th>
<th>Maize*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>57.8</td>
<td>75.0</td>
</tr>
<tr>
<td>Protein</td>
<td>22.9</td>
<td>8.5</td>
</tr>
<tr>
<td>Fat</td>
<td>1.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Fiber</td>
<td>4.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Minerals</td>
<td>3.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*the rest is water

1.2 **Advantages of Growing Haricot Bean**

1. It allows for double cropping in a season using early maturing cultivars
2. It serves for consumption and as a source of cash to farmers
3. It contributes towards a balanced diet because of its high protein content
4. It is convenient for intercropping because of its short growth duration and diverse growth habit
5. It can serve as a rescue crop whenever long duration crops fail due to unfavourable growth factors and
6. It serves as an export commodity to earn foreign currency: it s the main exported pulse crop in the country

1.3 Productivity
The national average yield of haricot bean in Ethiopia is 1.26 tone ha\(^{-1}\) (12.6 quintal) while that of the southern region is 1.14 tone ha\(^{-1}\) (11.4 quintal) (Fig. 3). The world average yield is 0.80 tone ha\(^{-1}\) (8.0 quintal), which is lower than the national average. However, farmers can increase bean productivity to 2.5 tone ha\(^{-1}\) (25 quintal) by using improved production technologies, which is an improvement of almost 100%.

1.4 Factors Limiting Haricot Bean Production-
Among the constraints limiting haricot bean production the following are the main ones:-
  • Sowing out of the proper time
  • Inadequate land preparation
  • Not using the correct planting density
  • Inadequate weed control
  • Poor disease and insect pest protection measures
  • Lack of using improved varieties
  • Inadequate use of fertilizers and certified seed
  • Loss of soil fertility
  • Drought
  • Storage pests
  • Low emphasis by concerned bodies in terms of training, input provision and follow-up, as compared to cereals
1.5. Adaptation

Haricot bean is grouped under the lowland pulses category. It is best adapted in areas with a warm temperature. Areas having mean air temperature between 18 and 24 °C are best suited for its production.

Haricot bean can be successfully grown in non acidic and well drained soils. Ideally, the soil pH should be between 6.0 and 7.5. The pH should not be below 5.0 or above 8.0.

In Ethiopia, it can be grown in areas with elevations between 1400 and 2000 mts above sea level receiving an annual rainfall of 350 to 1100 mm. It requires about 300 to 400 mm of water during its growth period. Haricot bean is susceptible to both scarcity and excess of moisture. Lack of moisture especially during flowering and seed filling phases is most detrimental to yield. Thus, it is advisable to maintain available soil moisture above 50% during these developmental phases. It is also essential to avoid drainage problems by avoiding fields prone to waterlogging and by preparing efficient drainage channels.
2. IMPROVED TECHNOLOGIES AND PRACTICES ENHANCING HARIROT BEAN PRODUCTIVITY

2.1 Use of Improved Varieties

Use of adapted high yielding varieties is one of the most tested means to enhance productivity. Adoption of this technology contributes hugely in minimizing the gap between the current average yield and the attainable yield that could be realized through adoption of improved technologies.

There are many improved varieties of haricot bean released in the country (Table 2). These varieties differ in growth habit, growth duration and seed characteristics. Farmers have to make the right choice in order to get the full benefit from use of improved varieties. The following are important points that should be considered in identifying the appropriate varieties:

   a. Adaptability

   A given variety needs to be adapted and grow well under the prevailing soil, rainfall and other climatic factors of an area in order to be productive. Production areas vary in their growth environment, which includes soil factors, temperature, rainfall amount and distribution, pest occurrence, and length of growing season. A variety that performs best in a certain environment may not be as productive in another area. It is possible to identify adapted varieties from comparative yield tests made in the target environment or other environments with similar growth factors. Haricot bean consists of varieties that vary widely in growth duration that generally differ between two and five months. For instance, areas with short growing season need to select varieties with a short growth cycle, which can grow and mature within the season. On the other hand, indeterminate climbing types have a long growth cycle and need to be grown in areas with longer growing season.
Table 2: Haricot bean varieties for domestic consumption and export used in southern Ethiopia.

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Year released/recommended</th>
<th>Seeding rate (kg ha(^{-1}))</th>
<th>Growth duration (days)</th>
<th>Growth habit</th>
<th>Major use</th>
<th>100 seed wt (g)</th>
<th>Seed color</th>
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<tbody>
<tr>
<td>SARI-1</td>
<td>2011</td>
<td>90-100</td>
<td>90-110</td>
<td>Indeterminate bush</td>
<td>Domestic consumption</td>
<td>17.3</td>
<td>Cream</td>
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<tr>
<td>Hawassa Dume</td>
<td>2008</td>
<td>90-100</td>
<td>85-110</td>
<td>Indeterminate semi-bush</td>
<td>Domestic consumption</td>
<td>21.5</td>
<td>Dark red</td>
</tr>
<tr>
<td>Ibbado</td>
<td>2003</td>
<td>90-100</td>
<td>90-95</td>
<td>Determinate bush</td>
<td>Domestic consumption</td>
<td>44.5</td>
<td>Speckled-red</td>
</tr>
<tr>
<td>Omo-95</td>
<td>2003</td>
<td>90-100</td>
<td>95-110</td>
<td>Indeterminate semi-climbing</td>
<td>Domestic consumption</td>
<td>17.9</td>
<td>Dark red</td>
</tr>
<tr>
<td>Nasir</td>
<td>2003</td>
<td>90-100</td>
<td></td>
<td>Indeterminate semi-climbing</td>
<td>Domestic consumption</td>
<td>20.9</td>
<td>Dark red</td>
</tr>
<tr>
<td>Red Wolayita</td>
<td>1974</td>
<td>90-100</td>
<td>90-110</td>
<td>Indeterminate semi-climbing</td>
<td>Domestic consumption</td>
<td>20.5</td>
<td>Dark red</td>
</tr>
<tr>
<td>Awash-1</td>
<td>1990</td>
<td>90-100</td>
<td>85-100</td>
<td>Indeterminate semi-climbing</td>
<td>Export</td>
<td>17.5</td>
<td>White</td>
</tr>
<tr>
<td>Awash-Melka</td>
<td>1999</td>
<td>90-100</td>
<td>85-100</td>
<td>Indeterminate semi-climbing</td>
<td>Export</td>
<td>17.3</td>
<td>White</td>
</tr>
</tbody>
</table>

\(^1\), Except Red Wolayita all are improved varieties

b. High yield potential

It is essential to choose high yielding ones among the varieties that are able to adapt and grow well in a given environment. Because, varieties differ in their yield potential even when grown under the same management and growth environment. Moreover, it is possible to include additional selection criteria deemed necessary under the prevailing production area. For example, tolerance to pertinent abiotic and biotic stresses such as drought, disease and pests. Participation of farmers during variety selection is vital to enhance the success of variety adoption through identification of desirable varieties.

c. Disease and pest resistance

Varieties greatly differ in their ability to resist disease and pests. Some could be highly resistant while others are moderately resistant or susceptible. Thus, it is crucial to select varieties that are resistant to important disease and pest problems of the target production area. Because, use of resistant varieties:-

- avoids unnecessary expense and
- for some diseases such as bean blight and anthracnose, it is practically the main option to control the problems.
d. Demand

A variety with a high demand would have a better market price and be more profitable to the farmer. There are a number of factors that influence demand of varieties. These include, characteristics such as colour, size, taste, cooking time and quality of the food. Also, haricot bean could be produced targeting local or export markets. Thus, farmers have to make sure that the characteristics of the varieties they choose are those which are needed by their customers. Haricot bean varieties are known to vary in their seed characteristics in addition to their great diversity in growth habit and morphology (for example Fig. 4)

![Varieties of Haricot Beans](image)

**Fig. 4:** Seeds of haricot bean varieties used in southern Ethiopia: seeds vary in colour and size


e. Cropping system

In addition to sole cropping, haricot beans can be grown under intercropping because of their suitable growth characteristics. It is vital to choose appropriate varieties that are suitable for the selected cropping system. Determinate bush and indeterminate bush types are convenient for large scale sole production (Fig. 5). Indeterminate climbing types require support when grown in sole stands (Fig. 6). It is necessary to identify the appropriate varieties with compatible growth habit for production of beans in association with other crops (See section 3).
Currently, improved varieties such as Hawassa Dume and Nasir are gaining acceptance among farmers in southern Ethiopia.

It is very important to note that farmers need to use improved varieties in combination with improved agronomic technologies. Otherwise, adoption of improved varieties alone will not guarantee realization of the full potential of the varieties.

**Fig. 5:** Determinate bush (left) and indeterminate bush (right) under sole cropping

**Fig. 6:** Indeterminate climbing types require support: types of support (left), on strings (middle) and on sticks arranged in tripod (right)  
Source: [https://www.google.com.et/?gws_rd=ssl#q=climbing+bean+images](https://www.google.com.et/?gws_rd=ssl#q=climbing+bean+images)
2.2 Choice of Seed

Once the right variety is identified the next step is to choose quality seed for sowing. Otherwise, it is not possible to attain the benefit from the selected variety. The contribution of quality seed for final grain yield is estimated to be between 15 and 20%. Good quality seed for planting should fulfil the following characteristics:-

   a. High germination ability

A seed that fails to germinate has no value for sowing. Moreover, a seed with reduced germination ability has little worth. In order for seeds to have high germination ability, they should have been:-
- harvested at full maturity and have to be well filled
- free from damages from weevil, other storage pests and pathogens and
- stored properly and not stored for a long period
  (For additional information see section 2.11).

   b. Free from disease

Some pathogens are transmitted from one crop season to the next through seed contamination. Thus, care should be taken to make sure that the seed is free from such pathogens.

   c. Free from weed seeds

If a seed contains weed seeds then both the crop and the weed start growth at the same time exposing the crop to severe competition from the very beginning. Moreover, the farmer will be exposed to unnecessary expense to control the weeds.

   d. Free from mixture with other crop/variety seeds

The seed should not contain seeds of other crops or varieties, which is required for agronomic and market reasons.

Use of certified seeds is preferable to guarantee quality if affordability and availability are not problems. However, farmers can use seed from their own produce by considering the points mentioned above in relation to choice of quality seed. Seeds for sowing should not possess a germination ability less than 75% irrespective of seed source.
2.3 Field Preparation

The field for haricot bean production needs to be ploughed three times:
- First ploughing as soon as the previous crop is harvested
- A second one a month after first ploughing and
- The third ploughing prior to sowing

2.4. Sowing Method and Seed Rate

Sowing in rows is recommended than broadcasting. Because row planting affords the following benefits:
- It is easier to carry out agronomic management practices such as cultivation, weeding, spraying and harvesting
- It allows a more uniform distribution of plants in the field (Fig. 7) leading to efficient utilization of soil resources and
- It gives more yield

In spite of the additional labour required for row planting it is more advantageous than broadcasting.

The spacing for haricot bean is 40 cm between rows and 10 cm between plants.

Unless a special row maker is available for row making, it is adequate to use a thinner digir when oxen ploughing is used for the task. To make row planting more convenient and faster it is possible to mark a long stick at 10 cm intervals and drop the seeds along the mark. Similarly, a rope can be used for the same purpose. It is advisable to put two seeds in each hill to guarantee the target plant density. Alternatively, a 1:2:1:2... option can be used to save seed. If two seedlings emerge at a given hill the weaker one should be rouged out within two weeks after emergence.

On average, 90 to 100 kg seed is need for one hectare. However, the rate and number of seeds per hill need to be increased for seeds of lower germination capacity in order to compensate for the failure in germination.

Sowing depth is generally between 3 and 6 cm though the exact depth depends mainly on soil moisture status. Sow deeper if the soil moisture content is low. Otherwise, a shallower depth is adequate.
2.5 Sowing Time

Planting time varies depending on the onset and duration of the rainfall season and the cropping system selected. Haricot bean is suitable for double cropping in southern Ethiopia because of its early maturity. The first crop is planted at the start of the short rains in March while the second comes after the first crop is harvested in July.

When planted in association with maize it is usually planted about four weeks after maize planting. Also, it can be sown after maize enters the final seed filling phase in relay intercropping, which is in August.

When it is planted as a sole crop during the short rains it should be sown as soon as the season’s rain starts.

2.6 Fertilization

Just like humans and animals plants require adequate food to grow well and be productive. They need macronutrients such as nitrogen and phosphorus more than any other mineral element. However, these nutrients are deficient in most agricultural soils. Thus, it is required to supply the plants with application of additional fertilizers. It is possible to provide this for beans in two ways:

   a. Chemical fertilizer

Even though haricot bean has the ability to fix nitrogen it is required to apply additional chemical fertilizers. Depending on the fertility status of the soil, applications of diammonium phosphate (DAP) up to the rate of 100 kg ha\(^{-1}\) and urea up to 50 kg ha\(^{-1}\) are required to enhance productivity. Both fertilizer doses can be side dressed at the side of the planting furrow just prior to sowing.
b. Biofertilizer

Plants require nitrogen more than any other mineral nutrient because of its critical role in growth and development. Moreover, this element is deficient in most farmers’ fields due to losses in leaching and volatilization. Thus, it is essential to use biofertilizers for haricot bean production in addition to chemical fertilizers. Use of biofertilizers is one of the natural fertility maintenance methods, which is accomplished by microscopic living organisms that live in association with pulse crops. These micro organisms are bacteria called *Rhizobia*.

The bacteria live in association with the plants in special structures called nodules. The nodules are found attached to the roots of pulse crops (Fig. 8). These bacteria change gaseous nitrogen in to mineral nitrogen, which is a form that can be utilized by the plants. For the bacteria to be effective in their function:

- Their number in the soil should be adequate
- They should be from an effective strain

To ensure that the above conditions are met the seeds should be inoculated with a selected strain of the bacteria just before planting. In haricot bean, inoculation would be especially critical if the land has not been used for haricot bean production previously. Once appropriate inoculation is done there is no need to repeat the practice every year unlike chemical fertilizers. The bacteria can survive for many years in the soil and perform their nitrogen fixation activity. Biofertilizers are available commercially for purchase and come with detailed inoculation procedures. Farmers can consult staff at the Bureau of Agriculture for advice concerning biofertilizers.

**Fig. 8:** Biofertilizer is effective when combined with phosphorus fertilization: inoculated seed with phosphorus fertilization (left), inoculated seed without phosphorus fertilization (middle) and uninoculated seed without phosphorus fertilization (right)  
Source: Demiss Zewdu, 2008
2.7 Weed Control

Farmers need to control weeds effectively in order to maximize their yield. The field should be weeded twice during the period between two weeks after sowing and flower initiation. Weeding is not advisable after the crop has flowered. Because such activity encourages flower drop and facilitates disease transmission within the field. Hand weeding is more appropriate for haricot bean though it is possible to use chemicals alternatively.

Shallow cultivation is useful to enhance growth because it helps to loosen the soil, which enhances infiltration, air exchange and weed control. Whenever cultivation is done it should be at a time of adequate moisture availability.

It is possible to use the chemical Alachlor for weed control. It is crucial to make sure that the chemical is not past its expiry date. Moreover, application instructions from the producer company need to be followed correctly.

2.8 Pest Control

a. Cut worm

Cut worm (Fig. 9) damages the crop at its seedling stage. It comes out of the soil at night and cut the plants at ground level. To prevent cut worm damage:-

- Check the field every morning for signs of damage and remove worms if observed
- Plant on time
- Apply good husbandry practices to enhance vigour of plants
- Increase rate of seeding

Fig. 9: Cut worm  
Source: http://www.infonet-biovision.org/default/ct/118/crops
b. Bean stem maggot

Bean stem maggot enters in to the lower part of the stem. Its feeding destroys the tissue causing the stem to swell and split (Fig. 10). This also leads to reduction in the formation of lateral roots. The maggot affects plants at their early growth phase. The damage is aggravated when crop growth is affected by unfavourable conditions such as lack of moisture.

In order to limit the damage from bean stem maggot:-

- Plant on time
- Maintain vigorous stand through optimum agronomic management
- Remove plants damaged by the maggot and
- Cultivate and earth-up plants two to three weeks after emergence to encourage recuperation of damaged plants especially when sufficient moisture is available

![Fig. 10: Bean stem maggot inside damaged stem (Source: http://www.infonet-biovision.org/default/ct/118/crops)](image)

c. Bollworm

The bollworm (Fig. 11) affects plants at early seed filling by entering and feeding on the immature pods. To prevent damage from bollworm:-

- Monitor the field regularly to detect the occurrence of the worm early
- If number is small remove worms and affected pods by hand
- If number is high spray with chemicals such as Cypermetrin and
- Grow the crop under intercropping with maize
d. Aphids

These are tiny insects, which damage plants by sucking the juice out of them (Fig. 12). The damage becomes considerable if they occur in large numbers.

To control aphids:

- If their number is large spray with a nim-based biopesticide or wash away the insects with a spray of soapy water

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Fig. 11: Bollworm

Fig. 12: Damaged bean plants by aphid infestation

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e. Bean weevil

This pest (Fig. 13) damages bean seeds in storage. To control this pest:-

- Clean the store adequately
- Dry the seed sufficiently before storage
• Do not store newly harvested seed mixed with seed that has already been stored for some time and
• Use chemicals such as Phostoxin, which are prepared against such storage pests

Fig. 13: Bean weevil  
Source: http://www.infonet-biovision.org/default/ct/118/crops

2.9 Disease Control

Haricot bean rust, anthracnose and bacterial blight are the most important ones among the various diseases that affect the crop. These pathogens mainly damage the leaves and to some extent pods to a varying degree (Fig. 14). To prevent damage from these pathogens:

• Use clean and disease free seed for sowing
• Use disease resistant varieties
• Limit field movement when plants are wet not to aggravate disease transmission and
• Practice crop rotation

Fig. 14: Bean rust (left), Anthracnose (middle) and bacterial blight (right) diseases  
Source: http://www.infonet-biovision.org/default/ct/118/crops  
http://www.ipm.ucdavis.edu/PMG/r52101111.html

2.10 Harvesting
Harvesting should be started when most of the pods (80 to 90% of pods) are ripe. At harvest the seed moisture content should not be less than 16%. Because if pods are too dry seeds could be lost to shattering. It is advisable to harvest early and make additional drying in a convenient place, before threshing. Harvesting in the morning while pods are still damp prevents loss of seeds due to shattering of over dried pods

The seed moisture content should not exceed 14% during threshing. Otherwise, it will cause seeds to split that leads loss of quality and market price. Threshing method can vary depending on the size of the produce and availability of resources. Threshing methods include:-

- Prepare them in bunches or put them in nylon bags and beat them with stick
- Spread canvas sheet on a prepared floor and drive tractor on it or
- use threshing machine

2.11 Storage

Further drying of seeds is needed before they are stored in order to reduce moisture content for safe storage. The seed moisture content of stored bean seeds should not go above 10%. Seeds that are not dried sufficiently before storage could be damaged easily by storage pests and pathogens. Moreover, the seed would lose its colour, taste and viability quickly. Also, when seeds are stored under high temperature environment they could be spoiled quickly. A seed with 10% moisture under a moderate temperature could retain its viability for about three years. On the other hand, a seed with 13% moisture under a similar environment can maintain its viability for one year. It is important to use chemicals against storage pests whenever there is a need for extended storage. It is essential to note that such chemicals need to be purchased from agents who are licensed for such activities and who can provide sufficient written instruction on how to use the chemicals. Additional help could be sought from staff at Bureau of Agriculture.

3. CROPPING SYSTEM

Because of its diversity in growth habit and morphology haricot bean is convenient to be grown under different cropping systems. It can be grown in sole stand or in association with other crops.
3.1 Sole Cropping

Sole cropping is practiced mainly with farmers having relatively greater farm size. It is the main cropping system adopted by farmers for haricot bean production in the Central Rift Valley areas. Moreover, large scale mechanized production of the crop is carried out through sole cropping. The technologies and practices discussed above can be followed for successful bean production under this cropping system.

3.2 Intercropping

Intercropping is growing of two or more crops together at the same time on the same field for a significant period of their growing period. Haricot bean is grown in association with many crops including maize, enset, sugar cane, banana and coffee, in southern Ethiopia. The most widely known system is the maize-haricot bean intercropping system. This type of cropping system is largely practiced by farmers facing land scarcity. Some of the reasons that make intercropping attractive are:

- It increases total production through improved land use efficiency
- It improves yield stability and contributes towards ensuring food security
- Slows spread of pathogens and pests in the field and
- It reduces fertilizer expenses

Though intercropping is a traditional practice known by famers it would be useful to adopt improved practices to make the practice more profitable. The following are the main considerations that need to be looked at to make the system more efficient in addition to those discussed under section three, above.

a. Identifications of component crops

The crops that grow together under intercropping need to complement one another, as much as possible. None of the components should be over aggressive and affect the growth of the other components. Farmers usually intercrop one principal crop with a second subsidiary crop to get an additional benefit. Under maize-haricot bean intercropping maize is the principal crop while bean is the subsidiary one. Thus, the intercropping system should be designed in such a way that yield of the principal crop is not markedly affected. For this reason over aggressive bean types are not usually advised to be intercropped. Indeterminate climbing types dominate the growth of maize by twining on it and this leads to yield loss. For simultaneous intercropping or when bean is introduced in the early stage of maize, determinate bush and indeterminate
bush types are preferred as components (Fig. 15). When bean is introduced late in the seed filling phase of maize, under relay intercropping, indeterminate semi-climbing and climbing types could be additionally used. Because maize has passed the stage where it would be damaged from competition with beans. As seen in Figure 15, indeterminate semi-climbing types can suppress growth of maize and reduce its performance under simultaneous intercropping.

Improved varieties such as Hawassa Dume and Ibbado are shown to be superior under intercropping with maize compared to the traditionally popular variety Red Wolayita. Thus, whether for sole cropping or intercropping systems adoption of improved bean varieties is more beneficial.

![Fig. 15: Maize-haricot bean intercropping with determinate bush (left) and indeterminate semi-climbing (right) bean types](image)

**b. Planting density of components**

Density of the principal crop, for example maize, should not be less than that when used under sole cropping. On the other hand, density of haricot bean should be adjusted to the extent that performance from the main crop (maize) is not compromised markedly. Thus, the density of haricot bean should be reduced up to half of the sole crop density. Whether in sole or under intercropping planting density should be determined based on moisture availability and soil fertility of the growth environment. If the association is a relay type it may not be necessary to lower the bean density because maize has already passed the stage where it would be influenced by competition.

**c. Spatial arrangement**

The spatial arrangement of the components should be in a form that facilitates efficient utilization of moisture, nutrients and solar radiation. Moreover, it should be convenient to carry out agronomic management practices such as sowing, weeding and harvesting.
Arrangements involving a 1:1 or 1:2 maize:bean distribution has been shown to be a preferred choice (Fig. 16). A 1:1 arrangement leaves more space and hence allows cultivation and earthing-up of both components. Especially, if the pulse component is sown before earthing-up of maize the 1:1 arrangement is preferable. On the other hand, if the pulse is introduced later through relay intercropping (see section 'd' below) the 1:2 arrangement would enable to get a better yield from the intercropped common bean. An intercrop association that is not designed properly is neither suitable for management nor convenient for growth and development of both components (Fig. 17).

**Fig. 16**: A 1:1 (left) and 1:2 (right) spatial arrangement in maize-bean intercropping.

**Fig. 17**: Improperly designed and managed association is disadvantageous

*d. Time of planting*

The component crops can be sown simultaneously or sequentially. The growth duration of the components, their moisture requirement and relative importance are some of the
points that need to be taken into consideration for determining planting time. As much as possible the main crop needs to be sown at the beginning of the season so that it can fully utilize the growing season and yield well. Moreover, components with long growth duration need to be planted earlier. Because of the bean’s relatively shorter growth duration it allows more options as shown below:

- It can be sown when maize approaches maturity in relay intercropping
- It can be sown simultaneously with maize and
- It can be sown at the early stage of maize, usually about a month after maize sowing

Many farmers introduce the bean component when they carry out the second cultivation, which is about a month after maize sowing. When beans are planted simultaneously or introduced early it is advisable to reduce density of the bean to avoid strong competition against maize.

On the other hand, when the bean is relay intercropped it is possible to apply the sole crop density as explained above. Relay intercropped bean may face severe shading from maize leading to poor performance. It is possible to improve light penetration and thus growth of the bean component by removing the lower leaves of maize (Fig. 18). Leaves could be removed after full germination of the bean plants.

Fig. 18: A better growth environment created for relay intercropped bean by removing lower leaves of maize: bean growing after leaf removal (left) and bean growing without leaf removal (right)

### 3.3 Crop Rotation

It is not advisable to grow haricot bean continuously on the same plot. Rather, it is wise to grow them in rotation with other crops. Because crop rotation decreases the risk of disease, pest and weed problems and helps to enhance productivity. For example, it can be rotated effectively with such crops as maize, wheat, sorghum and potato with a beneficial effect for all the crops involved in the rotation.
4. REFERENCES