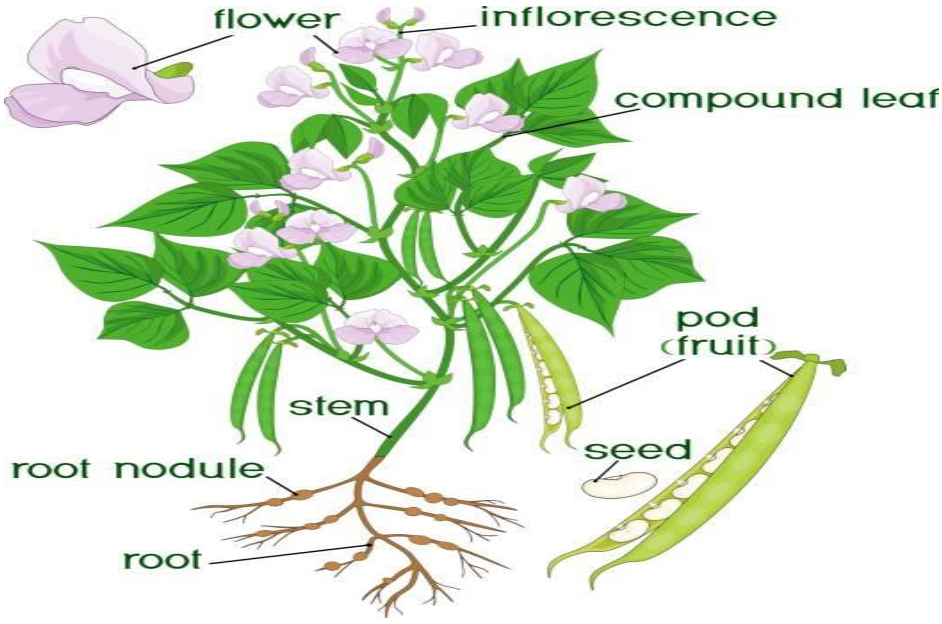
Agricultural Productivity Programme for Southern Africa

A training manual prepared for training farmers on

"**Characterization of common bean genotypes using morphological markers**"



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Preface

This manual is prepared by the authors to impart knowledge to Extension Officers, Crop Production Officers, Seed marketing retailers, Seed company representatives, Farmers and Representatives of Non-Governmental Organizations on how to distinguish the cultivars of common beans using morphological features. The method explained in the manual is non-destructive as the records or measurements are taken directly from the standing crop and there is no part of the crop removed or destroyed. The manual is written in a simple language for ease of comprehension but some botanical jargon is included which could not be avoided. There are also illustrations of bean features using full colour photograghs to enhance understanding. Where the actual common bean plant is available, both pictures and plant will be used concurrect.

Most importantly, insects and diseases causing damage to the bean crop in Lesotho are included in the manual explaining different levels of severity necessitating control measures and the alternative methods that could be applied. Full colour pictures of both harmfull insects and destructive diseases are included for illustration and better comprehension. These afore-mentioned picures will also help in making a preliminary assessment and diagnosis, after which confirmation will be done in the laboratory as a procedure.

It is anticipated that this manual will be a resourceful material enriching the knowledge of the targeted groups of agricultural professional on differentiating common bean cultivars.

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Chapter 1

1. Introduction

Common bean (*Phaseolus vulgaris* L.) is a leguminous crop originating from Andes and Meso-American where two distinct gene-pools are found. Where the two gene-pools converged in Peru and Ecuador, another gene-pool was formed named Phaseolin type 1. The gene-pools were characterized based on morphology, seed protein, allozymes and molecular markers.
From Peru and Ecuador, common beans were disseminated north to Colombia, Central America and Mexico, and south to Bolivia and Argentina, respectively. They radiated out of these areas to Europe, Africa and Asia through trade by Portuguese and Spaniards. They are now grown in large amount in India, Brazil, China, United States of America, Uganda, Tanzania, Kenya, Burundi, Rwanda and Cameroon. All African countries are producing common bean in varying amounts for home consumption, local market and export.

Through natural evolution, plant breeding and genetic engineering, there are now many cultivars produced differing in a number of characteristics such as vegetative, reproductive and seed parts. Vegetative parts entail leaves, stems and petioles, while reproductive parts encompass flowers and pods, seed covers, shape and colours. The variations in these characteristics assist in identifying common bean cultivars. Some features of the common beans are changing with environments and are controlled by many genes, while others remain unchanged cross all environments and are controlled by one or few genes. Those that change in response to differing environments are measured, thus height, areas, whereas those that are inelastic are immeasurable, thus kind and forms.

Both plant breeders and agronomist use the features to distinguish cultivars but most of the farmers and extension officers do not know how to use them to differentiate the cultivars. There is therefore a need to train both extension officers, farmers and seed retailers how they can use

the differing characteristics to separate cultivars. This training will eliminate a problem of having mixing many cultivars that are closely related or look alike.

Chapter 2

2. Morphological features of common beans

2.1. Introduction

Common bean is crop plant constituted by many parts which include among others; leaves, stems, roots, flowers, pods and seeds. The parts are formed sequentially as the crop grows from emergence above soil surface to harvesting when the crop dries off. The variations existing in these parts within common bean crop and amongst cultivars are of paramount importance in distinguishing the cultivars, hence a need to know them thoroughly. To distinguish different cultivars, some aspects of plant taxonomy have to be applied, which are mostly used to classify plants according to kingdom, phylum, class, order, species and genus. For the sake of this manual, differentiation will be made at species level only.

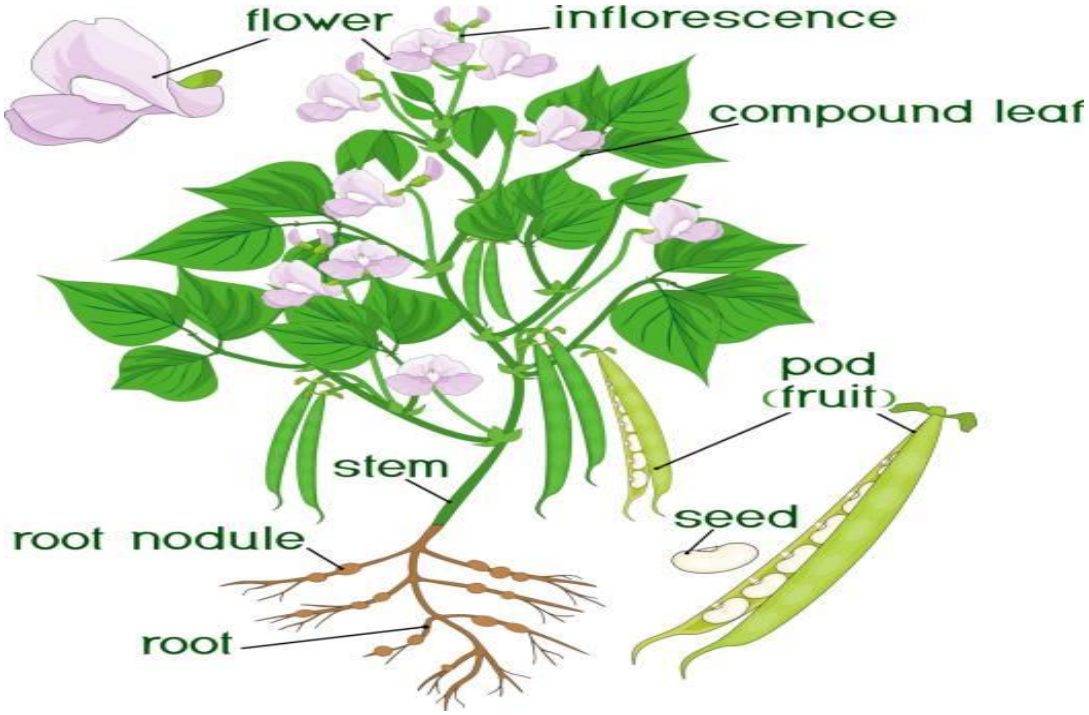


Fig 1. Whole bean plant with parts labelled

2.2. Description of plant parts

2.2.1. *Leaves*

Shape: the leaf of common been is broad, membranous and thin taking a shape of a heart called cordate, thus lanceolate. The leaf can grow 6 – 15cm long and 3 – 11 cm wide with acute apex, cordate base and an entire margin around the leaf. The surface of the leaf varies from smooth to a rough covered by sparsely or densely distributed hair. They colour of the leaf is generally green but depend on the environment in which it grown. If more nitrogen is applied, deep green colour is observed. But where it low in amount, yellowish green colour may be discernible. Bean crop has a trifoliate compound leaf consisting of three leaflets, one situated at the tip of petiole while the other two are just the below located opposite each other. The compound leaves alternate on the stem. Petioles are 3 – 6cm long and attach the leaves to the stem. The stipulates are triangular to lanceolate, spreading or reflexed. The arrangement of the veins in the leaf are netted, hence net venation.

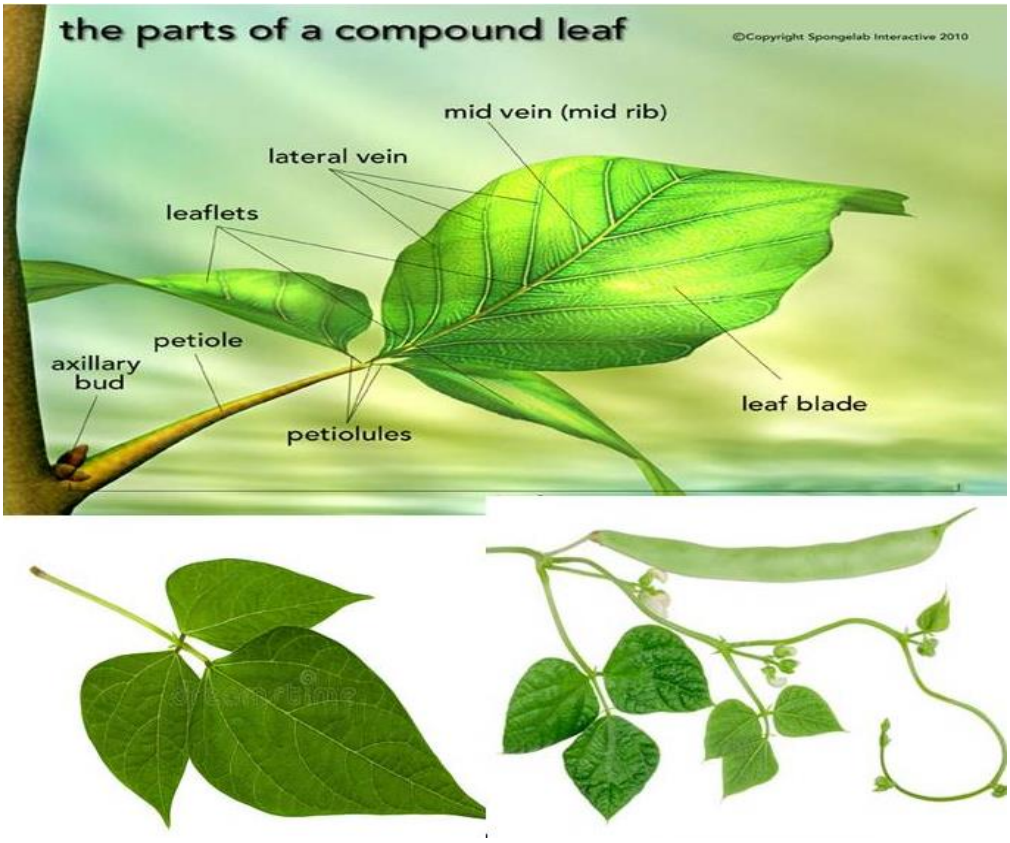


Fig 2. Bean leaf

2.2.2. Stem

The stem of climbing cultivars are 2 – 3 m tall with 12 – 15 elongated nodes or even more, while erect bushy cultivars are 20 – 60 cm tall having 4 – 8 nodes terminating in the inflorescence. There are some cultivars that are semi-climber falling between bushy and climbers characterized by weak runners. The bushy cultivars are determinate ceasing to grow with an advent of flowering, while indeterminate cultivars grows continuously as long as the environment is conducive for its growth. The stem may be green, light yellow or purplish in colour covered by sparse or dense hair resembling the stem colour. The surface of the stem maybe smooth to rough depending on the cultivar. The stem is cylindrical in shape and solid inside from emergence to the beginning of grain filling stage, after which it becomes fibrous. Most of the climbers need to

be supported by staking them with sticks or planted next to fence, house or with another tall crop like maize.

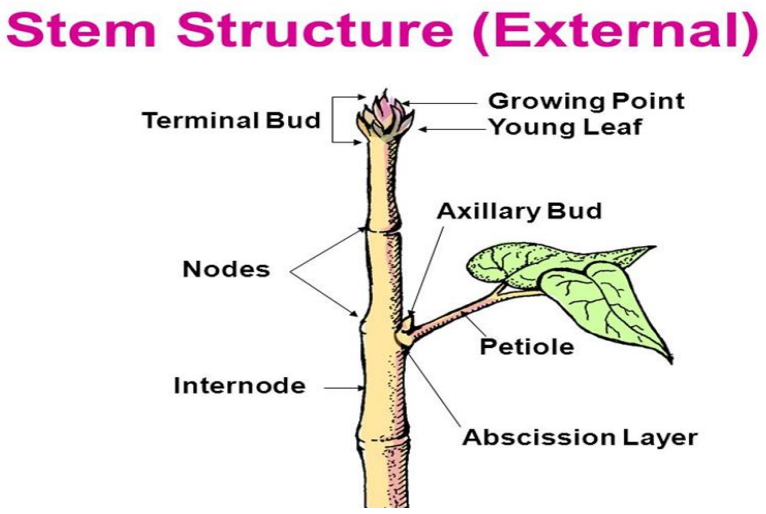


Fig 3. Bean stems

2.2.3. Flower

Common bean is al annual, self-pollinated, diploid plant with a chromosome number of 2n = 22. Pollination takes place at the time when the flower opens. The flowers are clustered in two to four in one place. The inflorescence is up to 7cm long with 2 – 10 nodes. The bracteoles are ovate to lanceolate, 3.5 -6.0 long and 2.5 – 4.0mm. Flowers are small, 13 – 18 mm long and white, yellow, pink, pale purple or violet in colour. Flowers are in an irregular form constructed of five petals called banner, wings or keel.Both female and male parts are borne in the same flower consisting of ovaries that produce ovules (eggs) and anthers producing pollens (sperms), respectively. Pollination and fertilization of ovule and pollen takes place before the flower opens, hence called self-pollinated plant. The fertilized ovary develops into a seed that is eaten.

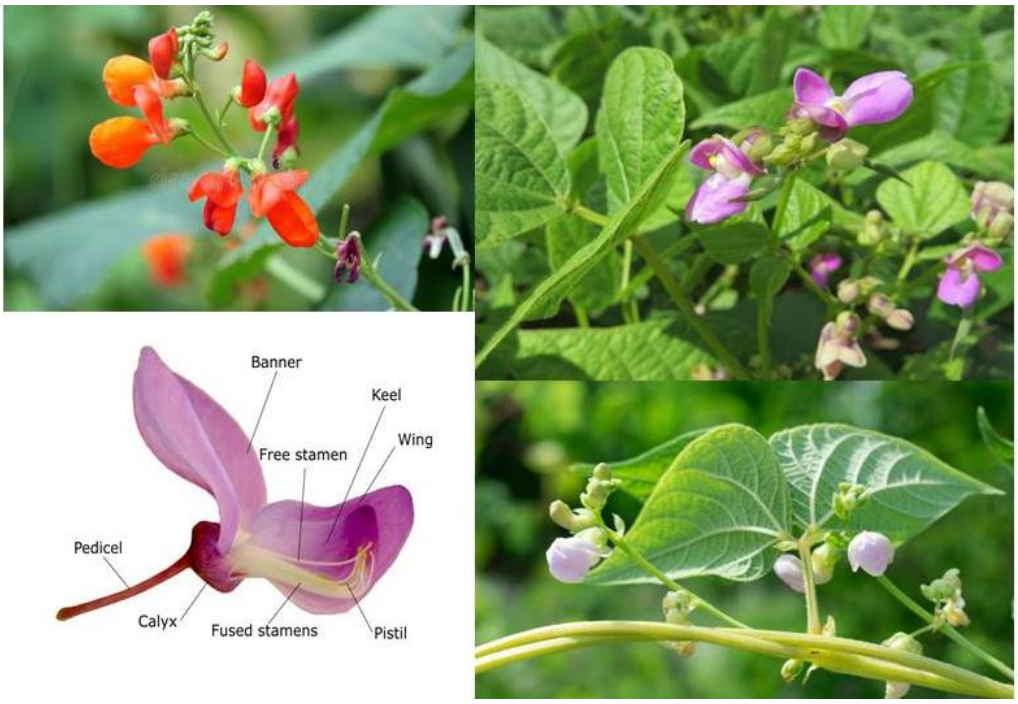


Fig 4. Bean flower

2.2.4. Seed

It is a ripened ovary formed from pollination and fertilization of pollen and ovule within the flower of the same plant. Seeds take 20 – 40 days to mature after fertilization depending on the cultivars. They are variable in colour, size and shape. The colour of testa may be white, yellow, greenish, buff, pink, red, purple, brown, black, mottled, blotched or striped. The length, breadth and thickness are variable, being 7 – 16 mm long and 2.5 – 5.5 mm wide. Some cultivars have different colours around the hilum. The shape of seed may be round, elliptical, somewhat flattened or oblong. The endosperm is absent and germination is epigeal. The seed can be viable for 4years when kept at moisture content of 12 – 15%, relative humidity of 4% and storage temperature of -4^0 C.

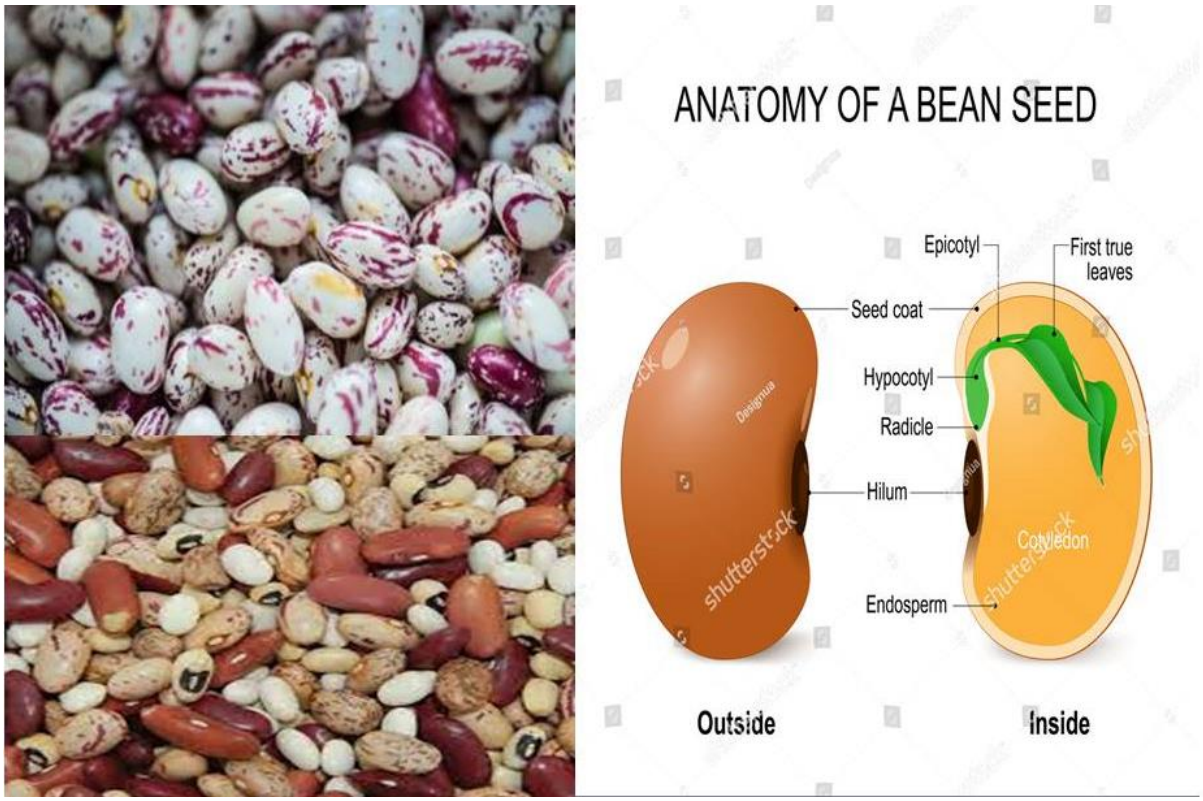


Fig 5. Bean seed

2.2.5. Seed Pod

This is a shell that contains 10 – 20 seeds within it depending on cultivar and environmental conditions. They are slender, straight or curved and glabrous. Each pod is 10 – 20 cm long and 0.8 – 1.0 cm wide with a sharp apex. The colour of pods is light to dark green with or without red or purple stripes. The anatomy of the pod walls and structure of the ventral and dorsal suture fibers play an important part in determining the twisting of the ripe pods in an opposite direction to release the seeds. Pods are usually explosively dehiscent. The cross-section may be pear, round, oval, finger of eight or flat shaped.

Fig 6. Seed pod

2.2.6. Roots

The root system of common bean consists of tap root which grows down in the soil to the depth of 1.2m to 1.7m depending on the type of soil and soil moisture content. From the tap root, lateral roots, 'sometimes called adventitious roots', grow horizontally confining themselves to the depth of 20 to 40 cm below the soil surface. They profusely grow and die as their life-spans are short. Since they are legumes, nodules develop from the lateral roots having a shape of granules. These structures are responsible for capturing atmospheric nitrogen and converting it into absorbable form by plant system. The colour of nodules before dissection is somehow beige, but once they start to be active capturing nitrogen, the colour changes to between maroon to red.

Chapter 3

3. Application of morphological features in characterization of common beans

Variations that exist in the morphological features within bean crop species facilitate identification of different cultivars bred and grown by farmers in the fields. There are, however, many features which do not vary and maintain the uniqueness and identity of the common bean species. The ones that vary assist farmers, agronomists, plant breeders, crop physiologists alike in distinguishing the cultivars, though some cultivars are so close to each other that distinguishing them is a futile effort, necessitating much powerful discriminatory tools such molecular markers.

Nonetheless, International organizations have devised a tool to be used by all the people interested in distinguishing cultivars of all cultivated crops including fodder. The tool has been accepted world-wide and was made to be adopted by Agriculturists in general dealing with characterization of crops. The name designated this tool is" descriptor"'. Some call it "descriptor list". It was developed by International Board of Plant Genetic Resources Unit of Food and Agriculture Organization in Rome, Italy. It is therefore with this reason that we want the players in crop production to be taught about it and adopt it for distinguishing cultivars of common beans. The type of data to be collected after which they are analysed to differentiate the cultivars are as follows;

3.1. Preliminary characterization and further evaluation

3.1.1. Vegetative data

3.1.1.1. Leaflet length: measured on the terminal leaflet of trifoliate leaf from pulvinus to the leaf tip of the plant grown under field condition.

3.1.1.2. Plant type:

a) Determinate bush,
b) Indeterminate bushy with erect branches,
c) Indeterminate bushy with prostrate branches,
d) Indeterminate with semi-climbing main stem and branches,
e) Indeterminate with moderate climbing ability and pods distributed evenly up the plant,
f) Indeterminate with aggressive climbing ability and pods mainly on the upper nodes of the plant,
g) Others.

3.1.2. Inflorescence and fruit

a) Number of nodes on the main stem from the base to the first inflorescence,
   Take the number from five plants.
   (i) For indeterminate plants, count from the base of the first auxiliary inflorescence,
   (ii) For determinate plants, count from the base to the terminal inflorescence,
b) Number of days to flowering from emergence to the stage where 50% of the plants have set flowers,
c) Number of buds per inflorescence: average number of flower buds from ten plants examining one inflorescence from each plant,
d) Colour of standard: In freshly opened flowers. The colours of freshly opened flowers are highly changeable after opening.
   (i) White
   (ii) Green
   (iii) Lilac
   (iv) White with lilac edge
   (v) White with red stripes
   (vi) Dark lilac with purple outer edges
   (vii) Dark lilac with purplish spots
   (viii) Carmine red

(ix) Purple

(x) Others

e) Colour of wings: in freshly opened flowers.

(i) White

(ii) Green

(iii) Lilac

(iv) White with carmine stripes

(v) Strongly veined in red to dark lilac

(vi) Plain red to dark lilac

(vii) Lilac with dark lilac veins

(viii) Purple

(ix) Others

f. Pod colour: from fully expanded immature pods.

(i) Dark purple

(ii) Carmine red

(iii) Purple stripe on green

(iv) Carmine stripe on green

(v) Pale red stripe on green

(vi) Dark pink

(vii)Normal green

(viii)Shiny green

(ix)Dull green to silver grey

(x)Golden or deep yellow

(xii)Pale yellow to white

(xiii)Others

g. Pod length: Average length in centimeters of fully expanded immature pods from ten normal random plants.

h. Cross-section: From fully expanded immature pods.

(i) Very flat

(ii) Pear shaped

(iii) Round elliptic

(iv) Figure of eight

(v) Others

i.Pod curvature: of fully expanded immature pod

(i) Straight

(ii) Slightly Curved

(iii) Curved

(iv) Recurving

j.Pod suture strings

(i) Stringless

(ii) Few strings

(iii) Moderately stringy

(iv) Very stringy

k.Pod colour at physiological maturity

(i) Dark red

(ii) Red

(iii) Pink yellow

(iv) Pale yellow with colored mottling or stripes

(v) Persistent red

l. Pod wall fibres

(i) Strongly contracting (at dry maturity adhering around the seed) flesh type

(ii) Leathery podded (dry pod will not spontaneously open)

(iii) Excessive shattering (with strong twisting of dry pods)

m.Locules per pod: Number of locules from the longest pod of 10 random normal plants

n. Seed:

Seed coat pattern

(i) Absent

(ii) Constant mottled

(iii) Striped

(iv) Rhomboid spotted

(v) Speckled

(vi) Circular mottling

(vii) Marginal colour pattern

(viii) Broad striped

(ix) Bicolor

(x) Spotted bicolor

(xi) Pattern around the hilum

(xii) others

o. Seed coat dark colour

(i) Black

(ii) Brown, purple to Dark

(iii) Maroon

(iv) Grey, Brownish to Greenish

(v) Yellow to greenish yellow

(vi) Pale green to buff

(vii) Pure white

(viii) Whitish

(ix) White, purple to tinged

(x) Chlorophyll green

(xi) Green to olive

(xii) Red

(xiii) Pink

(xiv) Purple

(xv) Others

p. Seed coat light colour

Choose from the above listed light colours

q. Brilliance of seed

(i) Matt

(ii) Medium

(iii) Shiny

r. Seed shape

(i) Round

(ii) Oval

(iii) Cuboid

(iv) Kidney shaped

(v) Truncated fastigiated

3.1.3. Further characterization and evaluation

3.1.3.1. Vegetative data

a. hypocotyl length: average length in centimeters from ten plants measured when primary leaves are fully expanded.

b.hypocotyl pigmentation

(i) Purple

(ii) Green

(iii) Others

c.emerging cotyledom colour:

(i) Purple

(ii) Red

(iii) Green

(iv) White

(v) Very pale green

(vi) Others

d. leaf colour of chlorophyll

(i) Pale green

(ii) Medium green

(iii) Dark green

e. leaf colour of anthocyanin

(i) Absent

(ii) Present

f. leaf shape on the terminal leaflet of the third trifoliate leaf

(i) Triangular

(ii) Quadrangular

(iii) Round

g. days to maturity: number of days from emergence until 90% of the pods are mature.

h. leaf persistence : when 90% of plants on the plot are dry.

(i) All leaves dropped

(ii) Intermediate

(iii) All leaf persistent

i.plant height: average in centimeters at maturity from 5 plants measured at cotyledon scar to tip of the plant.

j.Stem diameter: measure in millimeters at maturity for plants at crop density.

k. Lodging:

(i) Apright

(ii) Intermediate

(iii) Lodged

i. Number of nodes at maturity: on the main stem.

3.1.3.2. Inflorescence and fruit

l.Flower bud size

(i) Small

(ii) Medium

(iii) Large

m.size of bracteole

(i) Small

(ii) Medium

(iii) Large

n. shape of bracteole

(i) Lanceolate

(ii) Intermediate

(iii) Ovate

o. bracteole/calyx length in relation (bracteole measured in relation to calyx)

(i) Shorter than or equals to

(ii) Up to 1/3 longer

(iii) Twice as long

p. calyx bracteole colour

(i) Green

(ii) Pale violet

(iii) Dark purple

(iv) Others

q.wing opening

(i) Parallel close wings

(ii) Wings moderately diverging

(iii) Wings widely diverging

r. style protrusion : protrusion outside the top of the keel

(i) Not protruding

(ii) Protruding

s. racemes per plant: average of 10 plant at crop density

t.Inflorescence length: average in millimeter from 10 plants examining one inflorescence from each plant.

u.pedicel length: average (in millimeter) from an oldest flower from 10 plants examining one inflorescence from each plant.

v.duration of flowering: number of days from first flower in 50% of the plants to the stage when 50% of the plants have stopped flowering.

w.Position of pods

(i) Base

(ii) Centre

(iii) Top

(iv) Combination of 1, 2 & 3

(v) Others

x.Pod width: average width of fully expanded immature pods from 10 random normal plants.

y.Pod beak length: measured in millimeters from the end of the last loculus.

z. pod beak position:

(i) Marginal

(ii) Non-marginal

(iii) Others

aa.beak orientation

(i) Upwards

(ii) Straight

(iii) Downwards

ab. Dry pod colour

(i) Dark purple

(ii) Carmine red

(iii) Purple stripe on green

(iv) Carmine stripe on green

(v) Pale red on green

(vi) Dark pink

(vii) Normal green

(viii) Shiny green

(ix) dull green to silver grey

(x) golden to deep yellow

(xi) pale yellow to white

(xii)others

ac. Pod per plant: average from 10 plants at crop density

ad. Seed per pod: average number of seeds from one pod selected from ten plants.

Ae. Apparent seed veining

(i) absent

(ii) present

af. Seed weight: weight of 100 seeds weighed in milligrams to the first decimal place at 12 – 14% moisture content.

Ag. Seed volume: volume in millimeters of ethanol 94% strength that is displaced by 100seeds.

Ah. Seed dimensions: average in millimeters of ten seeds from ten plants,

(i) length measured parallel to the 18elium

(ii) width

(iii) height from hilum to the opposite side

ai. Percentage seed protein of a check variety

(i) percentage

(ii) name of check variety

aj. Stress susceptibility and resistance

the reaction is measured in the scale of 1 -9 where

3=susceptibility

5=Moderately susceptible

7=highly susceptible

Conditions

(i) low temperature

(ii) high temperature

(iii) drought

(iv) high humidity

(v) salinity

(vi) soil acidity

Chapter 4

4. Agronomic practices

4.1. Seed-bed preparation

a. ***Riper*** – The field is worked first by using a ripper that breaks the chemical and plough pan. Chemical pan is formed as a result of accumulation of inorganic fertilizer at a particular level in the soil while plough pan result from ploughing at the same depth all the time, which hardens the soil at that depth. The two pans inhibit the penetration of water down the soil resulting in water-logging which kills the crop.

Fig 7. Ripper

b. Ploughing – The land has to be ploughed with mould-board plough either drawn by a tractor or oxen. The purpose of mould-board plough is to loosen the soil for proliferation of roots, aerate the soil to allow circulation and storage of air and water respectively, which plant roots need for survival and lastly to incorporate vegetative materials lying on the soil surface into the soil to decompose.

Fig 8. Mouldboard plough

c. Harrowing – This operation is undertaken to level the seed-bed and eliminate low lying spot, otherwise they will accumulate water causing water-logging. Besides, harrowing breaks large lumps of soil in order to make a fine tilth seed-bed that will enhance germination of the seeds. The operation also removes the trash or residues from previous crop.

Fig 9. Disc harrow

d. Sowing and seed-rate – seed of common beans are planted using a planter which is ox-drawn or tractor mounted, otherwise some farmers use hand-sowing which is not encouraged because of negative impact it has, such as unequal spacing between the lines and in between the plants even the depth in the soil at which the seed is placed not the same. With the planter, these are achieved through calibration exercise.

The spacing between the row is 90 – 100cm while between the plants in a row is 25 – 30cm. Plant population is 250, 000 – 300,000 plants per hactre depending on the weight of the seed from a particular cultivar. Planting depth for seed is 5cm. Seed rate per hactre is 35 – 45kg per hactre. Planting starts in October 15 to February 15 in lowland and foothills while in the Mountain areas is October 15 to December 15.

e. Fertilization – The amount, type and placement depend on the nutrients available in the soil, which will determine the amount of individual to be added. However, the blanket recommendation made by Department of Agricultural Research is 2:3:2(21)+Zn at the rate of 3000 – 350kg/ha or 2:3:0 (21) at the rate of 250 – 300 kg/ha. Nitrogen is only required during planting time to kick-start the crop, after which the crop can fix it for its use. Phosphorus has to be applied as basal dressing together with nitrogen and potassium. Phosphorus and potassium are not mobile in the soil, hence applied as basal dressing only. Fertlizer may be applied using ox-drawn or tractor mounted planter separating seed from fertilizer to avoid burning of seed. Broadcasting is also used where there is no planter.

Fig 10. fertilizer bag

f. Weeding – removal of weeds is done whenever they are observed in the field. Few weeks after planting, weeds emerge above soil surface depending on soil moisture content. High level of

emergence and infestation is expected if soil moisture is high, thus during rainfall. When soil moisture content is low, both levels of emergence and infestation are low. Weeding should be performed timeously when infestation level increaseas to avoid overshading and competition with a crop. It is recommended that under adequate moisture content, weeding is performed every three weeks for a period of nine weeks, after which the crop height is believed to be above that of weeds. It is then that weeding practices can be terminated. And let them to grow together with crop overshading the weeds. To continue weeding after this stage may result in unnecessary expenses of labour and time because prevalent weeds will not affect the crop yield significantly.

Weeding can be done manually by pulling them out with hand, removing them with hand-hoes or by using spike-tooth harrows, ox-drawn or tractor mounted cultivators. Herbicides are also used to control weeds which may be soil incorporated, pre-emergence or post-emergence application but the following precautions should be exercise; check for most prevalent weeds and get the rifgt herbicide for it, you may need to combine two or more herbicides depending on types of weeds, then read the label attached, apply as directed.

Fig 11. Hand weeding

4.2. Diseases and pests

Pathogens and pests that attack common beans infect all plant parts including bacteria, fungi, nematodes, and viruses. Pests vary widely too, from insects to mammals. Management or control of a disease or pest problem often relies on proper diagnosis and identification of the diseases causal agents.

4.2.1. Diseases:

1. Alternaria leaf and pod spot

Causal pathogen: *Alternaria alternata* (Fungus)

Symptoms:

- Small water soaked circular to irregular spots with pale-brown centers and reddish brown borders
- Leaf lesions
- Lesions on pods

2. **Bacterial Wilt**

Causal Pathogen: *Curtobacterium flaccumfaciens*

Symptoms:

- Young seedlings wilt and die
- Irregular lesions on the leaves and eventual drop off
- Discolored seeds with spots on pods

3. Anthracnose:

Causal Pathogen: *Colletotrichum lindemuthianum* (Fungus)

Symptoms

- Black sunken lesions on pods
- Veins on lower leaf surfaces turn black

4. Bean Root Rots:

Causal Pathogen: *Rhizoctonia solani, Pythium, Fusarium solani (*fungus)

Symptoms

- Yellow leaves /Drop off
- Stunted plants/ pods
- Slightly sunken reddish brown longitudinal stem cankers
- Water soaked stem rot near the soil line
- Hollow stems

5. Bean Rust:

Causal Pathogen: *Uromyces appendiculaters (*fungus)

Symptoms

Reddish dusty sports on surface of leaves

6. Bacterial Blight:

Causal Pathogens: *Xanthomonas campestris* pv *phaseoli*

Pseudomonas syringae pathovar *phaseolicola*

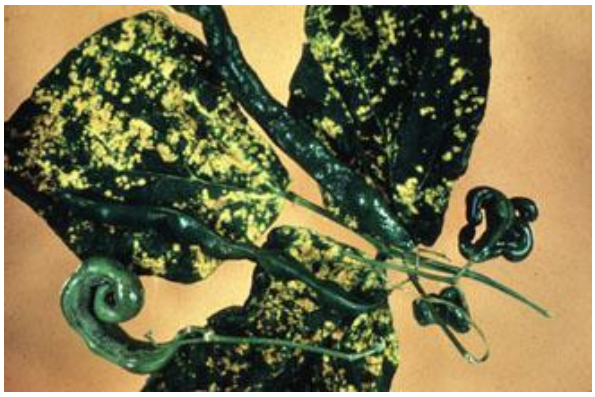
Symptoms

- Large dead areas (spots) on leaves
- Water soaked spots on pods

7. Mosaic Viruses

Causal Pathogen: Virus

Symptoms



- Stunted plants
- Mottling and vein dyeing of leaves
- Dying back of shoot tips
- Distortion and stunting of pods

8. Cercospora Leaf Spot:

Causal Pathogen: *Cercospora canescens* (Fungi)

Symptoms

Circular to slightly angular with a grey centre and a reddish border

9. Watery Soft Rot/ white mold

Causal Pathogen: *Sclerotinia sclerotiorum* (Fungus)

Symptoms

- White cottony growth on pods and stems
- Small, hard and black-seed like structures (sclerotia) form in the white mold growth.
- Rotted pods become wet and soft
- Affected plants often die

10. Damping-off

Causal Pathogens: *Rhizoctonia solani*

Puthium spp

Fusarium solani

Symptoms:

- Seed decay
- Discolored and soft stem tissues
- Toppling over of seedlings

4.2.2. Insect Pests

1. Cutworms


2. Bean leaf beetles


3. Aphids

4. Spider mites

4.2.3. Diseases and insect pests management

Management methods for common bean insect pests and diseases are limited and there is no method that is completely effective for diseases and pests' control; hence, integration of different disease/pests management (IDM/IPM) strategies is needed. These include:

- **Crop rotation**

  A minimum of two years between soybean crops in fields with a history of a disease
- **Use resistant soybean varieties and rotate among resistant varieties**
- **Management of residue**

  Tillage operations that place residue in close contact with the soil will promote the rapid decomposition of infected residue and destruction of the pathogen. In no-till or reduced-till systems, longer crop rotations and shredding common bean straw are effective.
- **Plant disease-free seeds.**
- **Cultural methods of trapping pests (pheromone traps and nets).**
- **Chemical Control**

  Seed treatment or foliar fungicidal sprays

4.2.4. Harvesting

This operation is undertaken several times after late grain-filling stage when pods have dried to 12 – 15% moisture. Harvesting of common beans takes two to three months depending on the cultivars because the pods do not dry at the same time. Besides, blooming of flowers is also continouos increasing gradually from the beginning until it reaches the peak where almost every plant flowers, after which flowering declines dramatically until few remains at the end.

4.2.5. Storage and packaging

There are several containers that can be used to store beans such as tins, bags, tanks, silos and mud stores. The type of container is not that important and matters most is the storage conditions prevailing in the store that will enhance the shelf-life of the beans. Temperature, relative humidity, hygienic conditions and dryness are pivotal for extended shelf-life of common beans. Fumigants, storage chemicals and disinfectent be applied.

Fig 12. Storage

5. Conclusion

Local production of common beans provides household with direct access to protien rich food. This manual is intended to identify desirable traits of progenies to be included in breeding programs for development of new common bean cultivars.

Agricultural Productivity Program for Southern Africa (APPSA-Lesotho)