Beans are rich in protein and high in the amino acids lysine and methionine, making beans nutritionally complementary to cereals, which are deficient in these two amino acids. Beans are the main source of protein in a vegetarian diet. As a vegetable, beans are highly susceptible to arthropod pests and diseases. Several arthropod pests including bean flies, aphids, thrips, leafhopper, whitefly, leaf beetles, pod borers, pod bugs, spider mites and broad mites cause significant damage to beans. For instance, up to 80% yield loss has been reported in various vegetable and grain legumes due to bean pod borer damage in Asia and Africa.

WHAT IS IPM?
Integrated pest management (IPM), an environmentally-sound and economical approach to pest control, developed in response to pesticide misuse in the 1960s. Pesticide misuse has led to pesticide resistance among prevailing pests, a resurgence of non-target pests, loss of biodiversity, and environmental and human health hazards.

WHAT ARE IPM PACKAGES?
The IPM Innovation Lab has developed and tested robust IPM packages, holistic suites of IPM recommendations and practices for the production of vegetables and other crops. Farmers who use IPM packages in planting, production, and throughout the supply chain see enhanced profitability in their crops. The recommended practices in IPM packages cover economically significant pest species over a wide range of cropping systems across the tropical world, with resulting benefits to human health and the environment.
bean pests and diseases

VIRUSES

Bean common mosaic virus

The typical symptoms appear as a light and dark green mosaic pattern on the leaves. It is often accompanied by distortion and rolling of the leaves. It also leads to reduced plant growth, delayed maturity and fewer pods. It has a worldwide distribution because of high rates of transmission through seeds. During the growing season, aphids transmit the virus as secondary spread. It can also be transmitted mechanically and in pollen.

Cucumber mosaic virus

A very common and devastating viral disease transmitted by aphids. Systemic symptoms consist of prominent leaf epinasty and mosaic, confined to a few leaves. Other symptoms consist of leaf curl, green mottle, blistering, and a zipper-like rugosity along the main veins. Plants may recover, but the virus continues to replicate in symptomless tissue. CMV is transmitted by aphids.

Bean yellow mosaic virus

Symptoms appear as striking yellow-green mosaic on infected leaves, which becomes more intense as the leaves grow old. Infected leaves are often cupped downwards, show wilting, necrosis, distortion and wrinkles. Infected plants show stunted growth and reduced production. Aphids commonly transmit the virus; however, the virus can easily be transmitted mechanically.

Curly top virus

Symptoms vary with growth stage, virus strain and environmental conditions. Infected plants have thick and brittle leaves that turn dark green. Plants show puckering and wrinkling of leaves. Plants infected at the early stage are stunted and produce very few pods while plants infected at a later stage mature early and produce small pods. The virus is transmitted by leafhoppers.

Fungal Diseases

Bean anthracnose (Colletotrichum lindemuthianum)

All above ground plant parts are affected. Infected seeds have small, dark brown-black lesions on cotyledons. Red-brown spots and lesions also develop on stems, petioles and leaves. The center of these lesions is light-colored and may show a pink ooze containing the conidia or spores of the fungus. A characteristic symptom appears on the lower surface of leaves, where veins turn red to purple and eventually black in color.

Ascochyta blight (Ascochyta rabiei)

All above ground plant parts are susceptible to this fungus. Brown lesions on seedlings may lead to damping-off-like symptoms. Foliar symptoms appear as round brown-colored lesions without margins. As the lesions grow, black raised spots appear in concentric circles on these lesions. Pod infection results in poor seed set and discolored and small seeds. Infected seeds and crop residue are a source of survival for this fungus.

Black root rot (Thielaviopsis basicola)

Initial symptoms appear as brown necrotic lesions on below ground stems and roots. These lesions often coalesce and form large black areas. In the case of severe infestation and stunting, premature defoliation and plant death may occur.

Charcoal rot/ Ashy stem blight (Macrophomina phaseolina)

Infected seedlings develop small, irregular, black-colored sunken lesions on stems near the soil line. Infection spreads upwards, plant growing tips may be killed or the stem broken. These lesions have a defined margin and often contain concentric rings. Infection of older seedlings cause wilting, chlorosis, premature leaf fall and death of plants. On older plants, several small black sclerotial bodies appear on the surface of stems. This “Charcoal dust” is characteristic evidence of this disease.

Fusarium root rot (Fusarium solani)

Symptoms appear as narrow, longitudinal brick-red streaks on below ground stems and roots. As the disease progresses, the streaks become dark and necrotic. In severe infections, the entire root system may be affected, resulting in stunted plants and premature leaf fall.

Fusarium wilt (Fusarium oxysporium)

Symptoms usually appear on older plants and begin as yellowing and wilting of lower leaves. The symptoms progress upwards until the entire plant turns yellow and wilted. Plants infected at young stages are stunted. The vascular system becomes reddish-brown and sometimes the roots may appear swollen.

Damping off and rot (Pythium spp., Rhizoctonia solani, Thielaviopsis basicola)

This disease can occur before or after plant emergence and can damage seedlings after transplanting. In pre-emergence damping off, seedlings fail to
bean pests and diseases

emerge. While in post-emergence, seedlings are stunted, wilted, and topple over.

Southern blight (*Sclerotium rolfsii*)

Initially the symptoms appear as yellowing of lower leaves and slight darkening and water soaking of the stem just below the soil line. Lesions on the stem expand rapidly, girdling the stem and causing permanent wilting of plants. A white mat of mycelium develops on the stem and spreads into the surrounding soil. Characteristic, brown spherical sclerotia appear on the mycelium and the base of the plant.

White mold (*Sclerotinia sclerotiorum, S. trifoliorum*)

Small, circular, dark green water-soaked lesions appear on leaves, branches, stems and pods. These lesions grow and become slimy. Infected parts may develop a white cottony appearance, as the mycelium is often visible on the surface under favorable conditions. A characteristic diagnostic feature is the development of black irregular-shaped sclerotia. Entire branches or plants may be killed.

BACTERIAL DISEASES

Common bacterial blight (*Xanthomonas campestris pv. phaseoli*)

Symptoms appear as small water-soaked spots on leaves, which gradually become large, necrotic and surrounded by a greenish-yellow ring. These lesions are found on margins and interveinal areas of the leaf. These lesions enlarge and result in defoliation or a burned appearance of the plant. Pods also show similar symptoms. Under favorable conditions, the lesions may have slimy bacterial ooze. Seeds from infected pods become shrunken and exhibit poor germination.

Bacterial brown spot (*Pseudomonas syringae pv. syringae*)

Symptoms appear as small, circular, necrotic spots surrounded by yellow margins. The spots enlarge and the centers of these spots may fall out, giving a ragged appearance to leaves. Water soaking and slimy ooze is generally absent. Lesions on pods results in distorted pod growth.

INSECTS

Bean pod borer (*Maruca vitrata*)
*Lepidoptera: Pyralidae*

The larvae bore into pods and eat seeds. Pods have small dark entry holes and sometimes frass is visible. Larvae damage buds, flowers and leaves by eating and webbing them together.

Bean lycaenid (*Euchrysops cnejus*)
*Lepidoptera: Lycaenidae*

Larvae feed on pods and damage on pods is characterized by round holes and feeding on pod contents.

Bean fly (*Ophiomyia phaseoli*)
*Diptera: Agromyzidae*

The pest is generally found in the petioles and stem. The larvae cause damage by mining the central core of the stem down to shoot junction. Due to disruption in the vascular system, plants wilt and die.

Cowpea Aphid (*Aphis craccivora*)
*Hemiptera: Aphididae*

The aphid feeds on stems and terminal shoots of seedlings, flowers and pods. Heavy infestations can kill seedlings, cause flower drop and pod shriveling. Aphids suck the sap from plants, which results in yellowing, curling, and deformation of leaves. Continuous feeding by aphids leads to yellowing, wilting and stunting of plants. Honeydew secretion leads to development of sooty mold. Aphids also vector several important viruses on beans including Bean common mosaic virus, Cucumber Mosaic Virus and others.
Southern green stink bug  
( *Nezara viridula*)  
Hemiptera: Pentatomidae

Feeding damage causes drying of shoots and shriveled pods and seeds.

Shield Bug ( *Piezodorus hybneri*)  
Hemiptera: Pentatomidae

Both nymphs and adults feed on pods, causing losses in fruit quality.

Garden looper ( *Chrysodeixis chalcites*)  
Lepidoptera: Noctuidae

Larval feeding causes skeletonization of leaves. Occasionally the leaves may be webbed together. Sometimes, the larvae may also excavate into buds. Frass may or may not be visible.

Broad mite  
( *Polyphagotarsonemus latus*)  
Acarina: Tarnsonemidae

Damage is usually confined to the lower surface of leaves. Symptoms include leaf distortions, shortening of internodes, blistering, shriveling, curling and cupping of leaves, and leaf discoloration. Fruits are malformed and scarified.

Leaf Miner ( *Liriomyza spp.*)  
Diptera: Agromyzidae

Larval feeding on leaves results in tunneling and formation of whitish trails or mines on the leaves. It results in reduced photosynthesis and yield. Heavy infestation can kill plants.

Corn earworm ( *Helicoverpa armigera*)  
Lepidoptera: Noctuidae

Young larvae prefer to feed on leaves and flower buds, but larger larvae feed on flowers and pods. Feeding holes filled with excreta are characteristic of larval damage. Severe damage leads to yield losses.

Sweet potato whitefly  
( *Bemisia tabaci*)  
Hemiptera: Aleyrodidae

Responsible for heavy crop losses worldwide, whiteflies damage beans by sucking and secreting sticky honeydew. Black sooty mold grows over the honeydew. Extensive feeding may result in stunting, poor growth, defoliation, and reduced yields.

Beet armyworm ( *Spodoptera exigua*)  
Lepidoptera: Noctuidae

Armyworm feeding causes skeletonization of leaves. Mature larvae feed singly on leaves and bean pods. Damaged pods will have holes in the pod and beans.

Bean thrips ( *Megalurothrips sititatus*)  
Thysanoptera: Thripidae

Thrips prefer to feed on foliage, but can also feed on flowers and fruits. Slightly infested leaves have silvery feeding scars on the lower leaf surfaces, while severely infested leaves turn yellow or brown. Infested pods are deformed and result in yield reduction.

Root knot nematodes:  
( *Meloidogyne spp.*)  
Nematoda: Meloidogynidae

Nematodes have a wide host range and are most severe in warm areas with long growing seasons. Plants infected by root-knot nematodes are generally less vigorous and healthy. Symptoms of nutrient deficiency and diurnal wilting are visible on leaves due to reduced efficiency of the root system. Presence of bead-like galls on roots is a characteristic of nematode presence.
bean IPM techniques

Soil preparation

A light, well-drained, well-prepared fertile soil results in healthy plants with minimal pest problems. Soil solarization and fertilization combined with compost inoculated with *Trichoderma* spp., neem cake, and Vesicular Arbuscular Mycorrhiza (VaM) fungus improves the nutrients available to the crop, priming the plant's own defenses and reducing the incidence of nematode, fungal or other plant diseases.

Seed selection

Select a high-yielding, locally preferred bean cultivar that is resistant or moderately resistant to diseases such as *Mungbean yellow mosaic virus*, *Bean Yellow Mosaic*, *Ascochyta blight*, *anthracnose* and *pests like bean flies and bean thrips*. Accessions or varieties having purple stems, thinner stems and smaller pith diameter are resistant to bean flies. AVRDC soybean accessions (G11569, PI171444 and PI227687), mungbean accessions (V4281 and one of its progenies, VC4035-17), *Vigna glabrescens* accession (V1160) and *V. sublobata* are found to be resistant to bean flies. Always use pathogen-free seed.

Seed treatment

Treating seeds with the *Trichoderma viride* or *T. harzianum* fungi, and *Pseudomonas fluorescens* and *Bacillus subtilis* bacteria protects seedlings from fungal and bacterial diseases, increases seedling vigor, and induces plant defense against pests. Sometimes hot water seed treatment is effective against bacterial pathogens like *Xanthomonas*.

Trap or Border crops

Trap crops like lentil, sum hemp, castor, and African marigold are effective against *O. phaseoli*, *M. vitrata*, *S. litura* and *H. armigera*. Mixed cropping and intercropping with other crops like maize, pearl millet and jute helps in reducing damage from whiteflies, *M. vitrata*, and *O. phaseoli*.

Sanitation

Before sowing, remove and destroy plant debris or infested plant material from the field to avoid fungal diseases. Remove weeds, which may serve as reservoir for diseases.

Crop rotation

Crop rotation with non-host or less susceptible crops also helps in reducing incidence of aphids, *H. armigera* and diseases like bacterial brown spot, *Ascochyta blight* and other soil borne diseases.

Fertilization

Neem cake or mustard oil cake alone, or in combination with compost inoculated with *Trichoderma* spp., is effective against soil borne diseases. Using neem and mustard oil cakes reduces the incidence of nematodes. Additionally, they contribute to the build-up of beneficial soil microbes that assist in nutrient absorption by the plants.

Traps

Setting up large, yellow sticky sheets in fields and use of water troughs helps to reduce aphids and whiteflies. Blue sticky traps help to reduce thrips. Pheromone traps can be used for *M. vitrata*, *S. litura* and *H. armigera*.

Biological control

Inundative release of ladybird beetles helps to reduce aphid populations. Use of neem-based biopesticides helps in managing aphids, *M. vitrata* and other pests. Egg
larval parasitoids Phanerotoma syleptae, and two larval parasitoids, Therophilus javanus and T. marucae are effective against M. vitrata. The parasitoids Trichogramma bactrae and Cotesia specularis are effective against bean lycaenid. Opicus phaseoli and Eucoilidea sp. are efficient parasitoids of O. phaseoli. The ladybird beetles (Menochilus sexmaculatus, Brumus suturalis, Harmonia dimidiata and Coccinella septempunctata) and green lacewing (Chrysoperla carnea) are efficient predators of aphids. Egg parasitoids such as Ooencyrtus malayensis, Trissolcus basalis, T. rudus, T. mitsukuri, T. nakagawai, Telenomus cyrus, T. pacificus and T. comperei and the reduviid predator, Sycanus collaris, keeps the Southern green stink bug under control. The egg parasitoids Trichogramma chilonis and larval parasitoids Campopleis chlorideae can be used against the common armyworm. Natural enemies such as Encarsia sophia and E. formosa are efficient parasitoids of whiteflies. Predatory mites such as Phytoseiulus persimilis and several species of Amblyseius, especially A. womersleyi and A. fallacis, can be used to control spider mites. Green lacewings are (Mallada basalis and C. carnea) also generalist predators of spider mites.

Microbial biological control agents

Bacillus thuringiensis, Beauveria bassiana and Metarhizium anisopliae can be used to manage M. vitrata and aphids. Biopesticides based on Paecilomyces lilacinus, Verticillium lecanii and neem are effective against bean lycaenid, green stink bugs and aphids. Spodoptera litura nucleopolyhedrovirus (SINPV) is commercially available in some countries. Maruca vitrata multiple nucleopolyhedrovirus (MaviMNPV) has been developed as a biopesticide. H. armigera nucleopolyhedrovirus (HaNPV) can also be used against H. armigera. Microbial control agents have little or no impact on parasitoids and predators of pests. For this reason, natural enemies will continue to serve as effective regulators of a variety of pests. By using these biopesticides, one may reduce/eliminate the use of synthetic pesticides.