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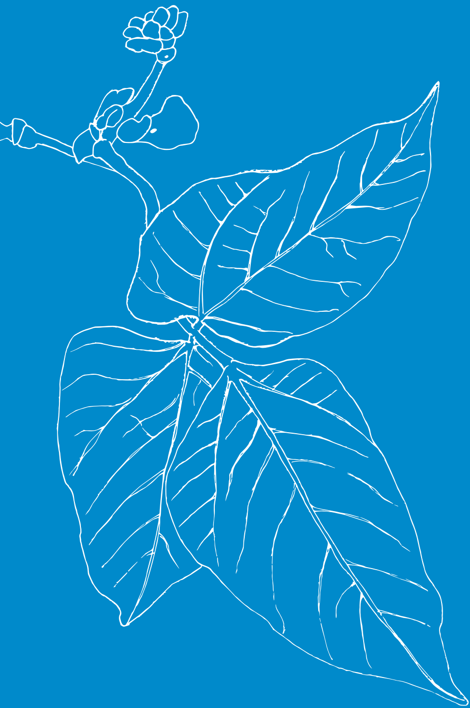
Australian Centre for International Agricultural Research

MUNGBEAN PRODUCTION GUIDE

FOR CAMBODIAN CONDITIONS



MUNGBEAN PRODUCTION GUIDE

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FOREWORD

The National Poverty Reduction Strategy (2003–05) of the Royal Cambodian Government committed research centres and extension systems to focus on small-scale farmers and emphasise the use of improved tools and management practices for cropping systems. Priority was given to diversifying and intensifying sustainable agricultural production, with few external inputs, and to developing cost-effective management practices.

The Australian Centre for International Agricultural Research (ACIAR) took on these challenges in 2003, beginning a project (ASEM/2000/109) to develop sustainable farming systems for a variety of crops. The project initially focused on maize, soybean, sesame, mungbean, peanut and cowpea in upland areas of Kampong Cham and Battambang provinces. The aim of the project series was to help reduce poverty and contribute to food security at the household and national levels in Cambodia through the development of technologies and opportunities for production of the non-rice upland crops. The research process has continuously involved engagement with farmers and local value chain networks for validation of local knowledge, documentation of case studies and identification of priorities for field research and demonstration.

A second ACIAR project (ASEM/2006/130) began in 2008 to increase production and marketing of maize and soybean in north-western Cambodia. The emphasis of this project was for on-farm adaptive trials to evaluate and improve the technologies and practices initially tested in 2007. This project was also expanded to integrate the production and marketing components of the system.

A third and final project, ASEM/2010/049 from 2012 to 2016, extended the focus to market-focused integrated crop and livestock enterprises for north-western Cambodia.

This project, in conjunction with two PhD projects, has made a significant contribution to understanding the impacts of climate change on upland agricultural systems in the region and for validation of adaptation options such as changing planting dates, reduced tillage, preservation of crop residues and introduction of new drought tolerant crops such as sorghum and sunflower.

The overall research program has provided a suite of new technologies and improved practices for upland agricultural production in a changing climatic environment. These crop production packages include improved varieties, fertiliser recommendations, rhizobium inoculation, integrated weed management, reduced tillage, retention of crop residues, crop rotation options as well as enhancing value chain networks and marketing.

The project series has made a significant contribution to capacity building for provincial staff from the Ministry of Agriculture, Forestry and Fisheries, Universities, non-governmental organisations and the private sector for the implementation of new technologies and improved practices in upland agricultural production systems.

This book is part of a series of publications produced by ACIAR in support of the ongoing roll-out of more productive, economic and environmentally sustainable upland cropping systems in Cambodia.

Nick Austin
Chief Executive Officer

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> ASEM/2000/109 Farming systems for crop diversification in Cambodia and Australia
> ASEM/2006/130 Enhancing production and marketing of maize and soybean in north-western Cambodia and
> ASEM/2010/049 Market-focused integrated crop and livestock enterprises for north-western Cambodia

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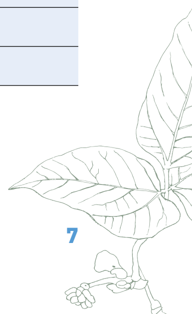
ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
AVRDC	Asian Vegetable Research and Development Centre
CARDI	Cambodian Agricultural Research and Development Institute
CMB	CARDI Mungbean
GRDC	Grains Research and Development Corporation
GVB	Green Vegetable Bug
IPM	Integrated Pest Management
ML	Megalitre
MYMV	Mungbean Yellow Mosaic Virus
SC	Soluble Concentrate
SL	Soluble Liquid
SUT	Suranaree University of Technology
WG	Wettable Granule
EWS	early wet season
Fe	iron
ha	hectare
IPM	integrated pest management
K	potassium
kg	kilogram
m2	square metre
mm	millimetre
Mo	molybdenum
MWS	main wet season
N	nitrogen
NPV	nucleopolyhedrovirus
P	phosphorus
S	sulfur
t	tonne
Zn	zinc



CROP DESCRIPTION

Mungbean is a short-duration legume crop. In Cambodia, it begins flowering after approximately 30 days and reaches maturity 70–90 days after sowing. Mungbean plants are branching, erect and self-pollinating. They have a rooting depth of 60–100 cm.

Mungbeans supply a human consumption market, so management for high seed quality is essential.

Key management tips

> Select soil that drains freely.

> Use high-quality seed, and check the germination percentage, disease status and varietal purity of seed.

> Fertilise according to soil test analyses, yield potential and field history.

> Inoculate seed using Nodulaid® Group I peat inoculant or SUT liquid inoculant.

> Calculate the required seeding rate to achieve a plant establishment of 20–30 plants/m^2 (25 kg/ha).

> Select row spacing to fit your farming system: wide rows offer more flexibility in sowing, and weed and insect management; narrow rows offer higher potential yields and greater weed competition.

> Assess potential weed problems and carefully plan weed control options (options for broadleaf plants are limited).

> Begin insect monitoring from the late vegetative (bud initialisation) stage (28–35 days after planting) to ensure timely and effective control decisions.

> Desiccate crops at 90% yellow to black pod stage. Maximise leaf dry-down to avoid dust sticking to seed during harvesting.

YIELD POTENTIAL FOR MUNGBEAN

In a series of five experiments in north-west Cambodia in 2008, mungbean yields ranged from 0.8 to 2.4 t/ha without rhizobium inoculant and from 1.1 to 3.2 t/ha with inoculant. The average yield for inoculated mungbean was 1.9 t/ha. Inoculation with rhizobium increased mungbean grain yield by 21% on average.

Figure 1. Farmers inspecting a demonstration of improved mungbean production in Samlout district, Battambang province. Photo: R. Martin

FIELD SELECTION

For machine harvesting, fields selected for mungbean should be fairly uniform in soil type and crop residue cover, and free from harvest impediments such as tree stumps and rocks. These are important considerations because of the low height of mungbean pods and to reduce the tendency for uneven crop maturity.

Field history

Mungbean is best included in the rotation after a cereal crop such as maize in the upland, or rice in the lowland.

Because mungbean is sensitive to several residual herbicides, care needs to be taken when selecting fields where residual herbicides have been used on the previous crop or fallow.

Soil management

Mungbean prefers well-drained soils with a medium to heavy texture. It does not grow well where there is soil compaction or waterlogging. In the upland, Ferrosols (Labanseak) and Vertosols (Kampong Siem) are ideal for growing mungbean (White et al. 1997).

Some rice soils, such as Toul Samrong (hard-setting heavy clays), are not suitable for planting mungbean. Rice soils typically have a hard pan at 15–20 cm (see Figure 2), and mungbean roots generally do not grow below this layer. Therefore, mungbeans planted after rice will require access to supplementary irrigation. The surface of Toul Samrong soil becomes extremely hard and cracks as it dries out.

Reference should be made to White et al. (1997) when choosing lowland soil types for mungbean planting.

Figure 2. Checking for hard pans on rice soils. Photo: R. Martin

Mungbean is well suited to no-till situations. Planting into standing maize or rice stubble should result in taller plants with pods higher above the ground, which makes machine harvesting easier.

No-till also increases the preservation of residual soil moisture after the main wet-season crop and reduces the risk of crop failure.

INOCULANTS

Mungbean should be inoculated with a Group I inoculant such as Nodulaid® (Figure 3). Seed should be sown into moist soil as soon as possible after inoculation, to increase the survival of the rhizobia.

Inoculation may be carried out by two alternative methods: coating the seed with a peat slurry (Nodulaid® product) or with a liquid inoculant (Suranaree University of Technology, Thailand).

Nodulation should be checked 30 days after sowing for sufficient numbers of active pink nodules (Figures 4). A nodulation failure can lead to a significant yield reduction.

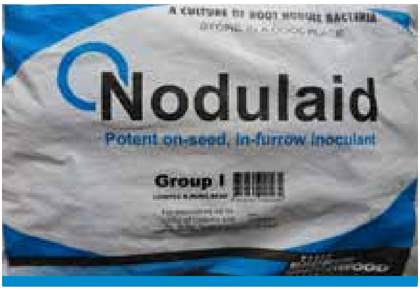


Figure 3. Nodulaid® Group I root nodule bacteria inoculum for cowpea and mungbean. Photo: R. Martin

Figure 4. Rhizobium root nodules. (left) and healthy nodules with pink flesh (right). Photos: R. Martin

LAND PREPARATION AND PLANTING

Land preparation

No-till planting into crop residues at the end of the wet season is essentially a three-stage operation (Figures 5–7):

1. Maize stover after hand picking needs to be chopped to form the surface mulch. If a combine harvester has been used, there is no need for chopping.
2. Pre-sowing herbicides are applied immediately after chopping.
3. Seeds are planted with a no-till planter 7 days after herbicide application.

Planting in upland

Mungbean can be planted into rice crop residues from mid-November to mid-January, depending on the rice harvest date and soil moisture content (Figure 8). Earlier sowings could be affected by late rain and waterlogging. Header trails should be removed before planting.

Burning rice straw dries out and hardens the soil surface, and can reduce establishment of mungbean.

Figure 5. Step 1: machine harvesting of maize to leave a no-till seedbed. Photo: R. Martin

Figure 6. Step 2: application of glyphosate and pre-emergence herbicides. Photo: R. Martin

Figure 7. Step 3: no-till planting into 5 t/ha maize residue using a three-row John Deere Maxemerge planter. Photo: R. Martin

Planting in lowland

Mungbean can be planted into rice crop residues from mid-November to mid-January, depending on the rice harvest date and soil moisture content (Figure 8). Earlier sowings could be affected by late rain and waterlogging. Header trails should be removed before planting.

Burning rice straw dries out and hardens the soil surface, and can reduce establishment of mungbean.

Figure 8. Planting into rice stubble. Photo: R. Martin

ROW SPACING

Mungbean is normally sown at 40 cm row spacing in Cambodia. However, it can be sown in row spacings from 18 to 100 cm. In Australia, narrow rows (<50 cm) have higher yield potentials where yields are likely to be greater than 1 t/ha. The yield increase may be as much as 10–15% as yields approach 2 t/ha.

Wider row spacing at 75 cm is recommended for no-till dry season sowing because:

- it is easier to check for insect pests
- planting into heavy crop residues is possible
- precision planters can be used to provide more accurate seed placement, resulting in better establishment and more even plant stands
- harvestability is improved because plants tend to grow taller, with pods higher off the ground
- input costs can be reduced by band-spraying insecticides and defoliants
- weeds can be cheaply controlled by inter-row cultivation or shielded spraying
- there is less risk of lower yields where soil moisture is limited.

Narrow rows (20–50 cm) are recommended under cultivated conditions on active floodplain alluvial loamy soils, because of:

- higher potential yields
- greater competition with weeds
- more even utilisation of moisture across the field.

PLANT POPULATION AND SOWING DEPTH

The aim should be to establish 20–30 plants/m^2 in non-irrigated dry-season crops and 30–40 plants/m^2 in irrigated situations.

Establishing a uniform plant density is critical to achieving uniform plant maturity across the field. The planting depth across the width of sowing machinery should be even, to ensure even crop emergence.

The number of seeds per kilogram of mungbean seed can vary widely. It may range from 10,000 to 20,000, depending on variety and growing conditions. Therefore, it is recommended that the sowing rate is calculated using germination test results, seed count per kilogram, the target plant population and establishment. The sowing depth should be 3–5 cm.

Calculating sowing rates

The following formula can be used to calculate sowing rates, taking into consideration:

- the number of seeds per kilogram (seed size or seed weight)
- the target plant population
- germination percentage (e.g. 90% germination = 0.9 in the formula)
- establishment—usually 80% (0.8 in the formula), unless sowing in adverse conditions.

$$\text{Sowing rate (kg/ha)} = \frac{\text{Target plant population/m}^2 \times 10{,}000}{\text{Germination} \times \text{establishment} \times \text{seeds/kg}}$$

Worked example:

$$\text{Sowing rate (kg/ha)} = \frac{25 \text{ plants/m}^2 \times 10{,}000}{0.9 \times 0.8 \times 13{,}500 \text{ seeds/kg}} = 26 \text{ kg/ha}$$

SEED QUALITY

Seed used for planting should ideally have germination percentages above 90%. Take care with some varieties as hard (dormant) seed levels may vary. A high percentage of hard seed can result in uneven germination and establishment. The level of hard seed (by test) should be kept to a minimum; above 20% hard seed is not advisable in seed for planting.

Seed kept on-farm for re-sowing can lose quality quickly. Farmers should therefore buy new seed every 2–3 years.

Seed quality can be reduced by seed-borne diseases, damage by grain storage insect pests, and weed seed contamination. It is recommended that farmers purchase seed with a certification label.

Before purchasing seed, check for damage by grain storage insects (see 'Storage pests', below).

VARIETIES

Mungbean varieties for Cambodian conditions were evaluated over a range of environments in 2004–06 by the Cambodian Agricultural Research and Development Institute (CARDI) (Ouk et al. 2009). Genotypes evaluated were from the Asian Vegetable Research and Development Centre (AVRDC), Australia and Thailand. These were compared with local farmer varieties.

The best-performing varieties were VC 4152 and VC 3541B (AVRDC), and ATF 3944 from Australia. All varieties outperformed local varieties, and farmers preferred the new varieties. These three varieties have been released by CARDI as CMB 1 (VC 4152), CMB 2 (VC 3541B) and CMB 3 (ATF 3944).

Mungbean seed originating from both Thailand and Vietnam can be purchased at most seed stores. However, quality is inconsistent, and germination tests should be carried out before large amounts of seed are bought.

GROWTH STAGES

Mungbeans have epigeal emergence—that is, their cotyledons appear above the soil surface. Following cotyledon emergence, the first of the trifoliate leaves begin unfolding. Alternate trifoliate leaves arise from all nodes above the unifoliate node.

Mungbeans are branching, erect or suberect and usually stand 0.5–1.0 m high when they have finished vegetative growth.

Mungbeans are determinate in their growth habit: vegetative growth stops when flowering commences, meaning that this will be the final height of the crop. However, they have an indeterminate flowering habit: they do not have a defined flowering period, and will continue to flower for as long as there is sufficient soil moisture. This means that a single plant can have flowers, green pods and black pods all present at the same time.

Under Cambodian conditions, mungbean plants progress from emergence to the beginning of flowering in around 30 days. Flowers are yellow or greenish yellow in colour (Figure 9) and are normally grouped in clusters of 5–15. If flowers abort, new flowers will appear if moisture conditions allow. Successive flushes of flowers and pods will occur while the soil stays wet.

Most of the pods form on the top third of the plant. Each pod contains 10–15 almost-round, green seeds.

Figure 9. Mungbean flowers. Photo: R. Martin

NUTRITION

Fertiliser recommendations are best based on soil test results, yield potential and field history.

Mungbean is a legume. When properly inoculated and planted into situations with low background soil nitrogen levels, mungbeans should fix sufficient nitrogen to support their own growth, and often leave some residual nitrogen for the following crop. As a guide, a 1.5 t/ha crop of mungbean requires a total nitrogen level of 100 kg/ha.

Basal application of 20:20:15 (N:P_{205}:K_{20}) + trace elements at 50–100 kg/ha is recommended, depending on soil fertility and yield potential. Because Cambodian soils vary widely in pH and natural fertility, the addition of trace elements is a precautionary measure.

WATERLOGGING

Mungbean does not tolerate waterlogging, so choice of soil type and irrigation management is very important. Waterlogging will reduce the ability of nodules to fix nitrogen and also results in induced nitrogen deficiency. For irrigation, it is estimated that mungbean requires 3.5–4.5 ML/ha of water.

Where waterlogging is expected, planting mungbeans onto hills or raised beds will allow better drainage.

Suggested timing of irrigation is:

- irrigation 1—about 7 days before the start of flowering, which is usually around 30 days after planting
- irrigation 2—early pod development.

Irrigating too late into the grain-fill phase may cause another flush of flowers to be produced, resulting in a split maturity in the crop. This will delay harvest and increase the risk of loss in quality.

WEED MANAGEMENT

Weed management tips

> Include cereal crops (rice, maize) in the rotation.
> Make sure seed for planting is free from weed seeds.
> Control weeds, especially those that reproduce vegetatively, before sowing.
> Use a post-sowing, pre-emergence herbicide as a priority.
> Apply post-emergence herbicides if necessary.
> Prevent weeds from setting seed during the crop cycle and post-harvest.

Descriptions of weeds commonly found in upland mungbean crops in Cambodia can be found in ‘Weeds of upland crops in Cambodia’ (Martin and Chanthy 2010).

It is important to control weeds before sowing. This applies especially to weeds that reproduce from rhizomes, stolons, tubers (*Cyperus rotundus*) or pieces of stem (*Commelina benghalensis*). If such species are present, the final cultivation should be replaced by application of glyphosate + 2,4-D.

Mungbeans are poor competitors with weeds. Weed competition reduces water use efficiency, interferes with harvesting and contaminates the seed sample.

Weeds such as *Ageratum conyzoides* can also be alternative hosts of diseases such as mungbean yellow mosaic virus (MYMV). The virus can be transmitted from the weed to mungbean by whitefly (*Bemisia tabaci*).

Herbicide options for control of broadleaf weeds in mungbean are limited. Emphasis must therefore be on selecting fields that do not have a problem with broadleaf weeds.

Table 1 shows herbicides that can be used in mungbean in Cambodia.

Table 1. Herbicides that can be used in mungbean in Cambodia.

Active ingredient	Mode of action group	Pre-plant	Post-sowing, pre-emergence	Post-emergence
2,4-D	I	✓		
Glyphosate	M	✓		
S-metolachlor	K		✓	
Pendimethalin	D		✓	
Imazethapyr	B		✓	✓
Fomesafen	G			✓
Clethodim	A			✓
Quizalofop	A			✓

Because herbicides are now widely used in Cambodia, herbicide resistance should be kept in mind when selecting herbicides for use in mungbean. Rotating grass crops (maize, rice) with mungbean enables rotation of herbicides with different modes of action. This will delay the development of herbicide resistance. However, herbicides are only part of an integrated weed management strategy to better manage weeds and reduce the likelihood of herbicide resistance developing.

Mungbean can be damaged by residues of sulfonylurea herbicides such as Almix® (metsulfuron methyl + chlorimuron ethyl) or Londax® (bensulfuron methyl), which are used in rice, or atrazine, which is used in maize. Under normal conditions, residues should not be a problem, but mungbean should not be planted as a replacement for failed maize or rice crops when herbicide residues could still be active in the soil.

Residues tend to stay in the soil for longer under alkaline or dry conditions, but these conditions are unusual for Cambodia.

HARVESTING AND DESICCATION

In Cambodia, mungbeans are traditionally harvested by hand. Two or three pickings are required because of the prolonged duration of flowering. Some farmers in Battambang are now picking once only and finishing off with a combine harvesting machine (Figure 10).

Machine harvesting requires even maturity across the field, and desiccation may be required to maximise yield and quality.

Glyphosate can be applied as a desiccant when 90% of pods are yellow or black. Harvesting can commence 8–16 days after herbicide application when the leaves are dry.

Harvest losses can result when mungbeans are too dry when harvested, due to both the increased risk of shattering and moisture weight losses.

Mungbeans are susceptible to wet weather at maturity, which causes seed swelling, discolouration, moulds and cracking. They should therefore be harvested as early as practical.

Figure 10. Combine harvesting mungbeans. Photo: Reaksa Sao

DISEASES

Disease management tips

- > Include cereal crops (rice, maize) in the rotation.
- > Make sure seed for planting is coated with fungicide.
- > Prevent damage from insects, birds and rodents, because such damage can allow pathogens to enter the plant through wounds.
- > Avoid stresses to the crop, including water stress and too much fertiliser.
- > Control weeds, because weeds are alternative hosts for many diseases.
- > Apply fungicide if appropriate.

Figure 11. Mungbean yellow mosaic virus symptoms on mungbean leaf. Photo: R. Martin

Mungbean yellow mosaic virus (*MYMV*)

Control of the vector *Bemisia tabaci* is the main option for control of MYMV (Figure 11), but it is important to be sure that the pest is present in the crop before application of insecticide. Integrated pest management (IPM) is the best approach to maintain populations of beneficial insects. IPM is also important to delay or avoid the development of insecticide resistance in important insect pests such as *Bemisia tabaci*.

Weeds that host MYMV, such as *Ageratum conyzoides*, should be controlled in and around the mungbean field.

Figure 12. Cercospora leaf spot on mungbean.
Photo: http://cropgenebank.sgrp.cgiar.org

Cercospora leaf spot

Cercospora leaf spot (Figure 12), caused by the fungus *Cercospora canescens*, is an important fungal disease of mungbean in Cambodia. It is most destructive under humid, tropical conditions. A range of registered fungicides effectively control this disease, including carbendazim, difenconazole, hexaconazole, mancozeb, propiconazole and thiophanate methyl.

Powdery mildew

Powdery mildew (*Erysiphe polygoni*) can be a serious disease of mungbean. It is favoured by warm, humid conditions.

Sulfur-based fungicides provide good control of powdery mildew. Carbendazim can also be used to control powdery mildew in mungbean.

INSECT PESTS

Insect management tips

> Keep weeds under control between crop plantings.

> Make sure seed for planting is coated with insecticide.

> Carefully check for pests and beneficial insects before applying insecticide.

> Avoid application of broad-spectrum insecticides in the vegetative stage, to preserve beneficial insects.

> Control weeds in and around the field, because weeds are alternative hosts for many insects.

> Apply insecticide if crop damage thresholds are exceeded.

Figure 13. Using a beat sheet to check on insect populations in mungbean. Photo C. Pol

Pest and beneficial insects commonly found in upland crops in Cambodia are described in 'Insects of upland crops in Cambodia' (Pol et al. 2010).

Insects can significantly affect the overall profitability of a mungbean crop by reducing both yield and seed quality. Accordingly, insect damage is one of the main reasons for price downgrades for mungbeans.

Crops should be inspected weekly from the vegetative stage to the beginning of flowering, and then twice weekly to the completion of pod fill. Crops that are producing buds, but not flowers, may contain damaging numbers of sucking insects that cause the buds to abort before the flowers open.

The preferred method for insect checking is to use a beat sheet between crop rows to identify, monitor and count insects (Figure 13). Mungbeans also usually support quite high populations of beneficial insects, which should be considered when selecting insect control measures.

Figure 14. Bean fly pupae (a) and adult (b)

Bean fly (*Ophiomyia phaseoli*)

Description

Adult bean flies (Figure 14) are tiny black flies, 3 mm long (about one-quarter the size of a common housefly), with one pair of transparent wings. Larvae are small, white maggots with brown heads. Pupae are pale yellow, straw-coloured or light brown, and can be seen sticking under the membranous epidermis, usually at the root–shoot junction.

Damage

Mungbean, cowpea, soybean and other legumes are attacked at seedling and vegetative growth stages.

Attacked seedlings may be wilted or dead, and leaves of older plants may be yellow and stunted. Damaged stems are thicker than normal and cracked lengthwise just above the soil.

Control

To avoid early incidence of stem fly, Sharma et al. (2011) recommend soaking seed in either:

- imidacloprid 17.8 SL at 5.0 mL/kg seed in 100 mL water for 1 hour, or
- thiomethoxam 25 WG at 5.0 g/kg seed in 100 mL water.

Spray either imidacloprid 17.8 SL at 0.2 mL/L or thiomethoxam 25 WG at 0.3 g/L at 15 days after sowing.

Figure 15. The green vegetable bug adult (left) and 3rd instar nymphs (right). Photos: R. Martin

Green vegetable bug (*Nezara viridula*)

Damage

Green vegetable bug (GVB; Figure 15) is the most damaging pod-sucking bug in mungbean as a result of its abundance, widespread distribution, rate of damage and rate of reproduction.

GVB is primarily a pod feeder, with a preference for pods with well-developed seeds. GVB also damages buds and flowers, but mungbeans can compensate for such early damage. Mungbeans remain at risk until pods are too hard to damage (i.e. very close to harvest).

Damage to young pods causes deformed and shrivelled seeds, and reduced yield. Seeds damaged in older pods are discoloured, and this reduces quality and price.

Natural enemies

It is best to take an IPM approach to managing GVB since this pest causes little or no damage to mungbeans in the vegetative stage. Spraying broad-spectrum insecticides early in the crop can seriously reduce the populations of beneficial insects. Natural enemies of GVB include the tachinid fly (*Trichopoda* spp.) and the wasp *Trissolcus basalis* (see 'Beneficial insects', below).

Control

The GVB spray threshold is one adult per square metre. Increasing the threshold to 0.3–0.6 GVB per square metre should be considered when high prices are offered for premium or sprouting beans. Crops should be inspected for GVB twice weekly from budding until close to harvest. Monitor populations using the beat sheet method, and spray once numbers reach the threshold.

Figure 16. The brown bean bug adult (left) and nymph (right). Photos: R. Martin

Brown bean bug (*Riptortus linearis*)

Description

Adult brown bean bugs (Figure 16) are 16–18 mm long and have yellow stripes along each side. The nymphs look like ants but can be distinguished from ants by the presence of the sucking mouthparts of bugs. The eggs are laid singly and are shiny brown.

Damage

Adults and nymphs of the brown bean bug pierce and suck contents from developing seeds and pods. This results in deformed or discoloured seeds. Mungbean, soybean, cowpea and sesame are attacked.

Mungbean crops should be inspected for brown bean bug from flowering to late pod fill. Check in the early morning before bugs become too active.

Control

IPM for brown bean bug is the same as for GVB.

Figure 17. Bean podborer. Photo: Pol C

Bean podborer (*Helicoverpa armigera*)

Description

Moths of bean podborer (Figure 17) are 35 mm long. Newly hatched larvae are white with dark heads. Larvae go though up to six stages (instars). As they grow, larvae become darker, with dark spots on their segments, but vary widely in colour. Medium larvae (10 mm long) have lines along the side of their body and a saddle of darker colour on the fourth segment back from the head. Large larvae are 35–40 mm long, and have white hairs around the head and on the body.

Damage

Helicoverpa can cause severe damage at all crop stages and all plant parts of mungbean. High populations in seedlings or drought-stressed crops can cause considerable damage if vegetative terminals and stems are eaten. This type of damage results in pods being set closer to the ground. Such pods are more difficult to harvest.

Once the mungbeans reach flowering, larvae focus on buds, flowers and pods. Young larvae are more likely to feed on shoot tips, young leaves and flowers before attacking pods. In drought-stressed crops, the last soft green tissue is usually the shoot tips, which are thus more likely to be totally destroyed.

Small pods may be totally eaten by *Helicoverpa*, but larvae usually eat only the seeds in large pods. Mungbeans are better able to recover from early damage than from late pod damage. However, in rainfed crops, where water is limiting, significant early damage may delay or increase the duration of podding, with consequent yield and quality losses. Damage to well-developed pods also results in staining of uneaten seeds from water entering the pods.

Control

The reproductive threshold for late flowering/early podding to late pod-fill stages is based on the rate of damage at late pod fill, with a range of 1–5 larvae/m^2, depending on the cost of control and the price of mungbeans. This threshold allows for possible yield loss in drought-stressed crops damaged by *Helicoverpa* at flowering.

Mungbeans should be monitored weekly during the vegetative stage, and twice weekly from early budding until late podding. A range of control options are available. Consideration needs to be given to the number and size of grubs, and the number of unhatched eggs in the crop. Knowledge of the level of insecticide resistance in *H. armigera* populations and the beneficial insect population will help in selecting the most suitable chemical for spraying.

Figure 18. Cluster caterpillar. Photo W. Leedham

Cluster caterpillar (*Spodoptera litura*)

Description

Moths of cluster caterpillar (Figure 18) are up to 25 mm long. The eggs are laid in clusters of up to 300 and are covered with a mat of grey–brown hairs. Mature larvae grow to up to 30 mm in length. They have black triangles in a line on both sides of the back, and the body narrows towards the head.

Damage

Larvae can almost completely destroy leaves, and heavy infestations also destroy buds and flowers.

Control

Sharma et al. (2011) recommends deploying pheromone traps at five per hectare for monitoring the pest population. Cluster caterpillar can be controlled by applying rynaxypyr 20 SC at 0.15 mL/L.

Figure 19. Tobacco thrip. Photo: A. Nicholas

Tobacco thrip (*Thrips tabaci*)

Description

Thrips (Figure 19) are very small—about 1 mm long—and barely visible to the naked eye. Larvae are either yellow or white. Older individuals are yellowish brown and move quickly.

Damage

Thrips can infest crops from the seedling stage, but are more common at the bud initiation stage through to flowering. Early crops might be more susceptible to damage because thrips migrate out of maturing cereal crops into mungbeans.

Thrips damage the seedling growing point and embryonic leaves. However, damage is not evident until the first trifoliate leaves open. Damaged leaves can be severely distorted and discoloured.

Damage to flowering plants can result in flower abortion and pod distortion. Deformed pods may be difficult to thresh, resulting in further yield losses.

Control

There are no thresholds for thrips at the seedling stage. It is unlikely that this pest will reduce mungbean yields except under extreme circumstances.

The spraying threshold for flowering plants is 4–6 thrips per flower at flowering and pod setting.

Management

Thrips are easily controlled with current systemic insecticides, such as imidacloprid or dimethoate.

Figure 20. Whitefly. Photo: R. Gunning

Whitefly (*Bemisia tabaci*)

Description

Adult *Bemisia* (Figure 20) are soft and whitish yellow when they first emerge from the nymph stage. Within a few hours, the wings become iridescent white as a result of a powdery wax. The body remains light yellow with a light dusting of wax. The female is 0.96 mm long, and the male is slightly smaller (0.82 mm).

Damage

Tobacco whitefly transmits MYMV, which is a serious disease in mungbean (see 'Mungbean yellow mosaic virus', above).

Management

Seed treatment with imidacloprid is effective against *B. tabaci*.

Figure 21. Cowpea aphid

Cowpea aphid (*Aphis craccivora*)

Description

Adult cowpea aphids (Figure 21) are 2 mm long, soft bodied, pear shaped and shiny black. Both winged and wingless forms occur. Two sharp points protrude from the sides at the rear of the body.

Damage

Aphids form masses on growing points, where they suck sap from flowers, pods and stems. Plants can be stunted and deformed. Leaves become very sticky from aphid excretion.

Control

Plants should be checked for aphids from flowering to maturity. Look for beneficial insects eating aphids. Also look for virus symptoms, as aphids may transmit viruses to other plants in the crop.

STORAGE PESTS

Figure 22. Cowpea bruchid adult (left) and bruchid eggs on mungbean seed (right). Photos: R. Martin

Cowpea bruchid (*Callosobruchus maculatus*)

The cowpea bruchid (*Callosobruchus maculatus*; Figure 22) infests seeds of legumes, especially mungbean and cowpea. It is the most important post-harvest storage pest of *Vigna* spp. throughout the tropics

Description

Adult beetles are 3 mm in length. The wing covers are orange with brown spots. Bruchids do not have a long snout like the true weevils, which infest cereals such as maize. Bruchid eggs are glued to the pod or seed (Figure 22b).

Damage

Crops may be first infested in the field before harvest, leading to transfer of insects with the harvested grain. This may also lead to re-infestation of seeds contained in the same storage facility.

When larvae hatch, they bore directly into the seed, where their development continues as they eat out the seed. Adults emerge through windows in the grain, leaving round holes that are the main evidence of damage. Insect damage can cause heating and extensive mould growth, reducing the quality of the grain.

Control

Grain storage pests are generally controlled by fumigants such as phosphine. However, under Cambodian conditions, this process is difficult and dangerous.

Addition of various vegetable oils to stored seed has been shown to give good control of bruchids without affecting seed viability. Sesame and sunflower oils, at a rate of 7–10 mL/kg of seed, have been found to be effective in preventing oviposition by bruchids.

Figure 23. Rice weevil. Photo: R. Martin

Rice Weevil (*Sitophilus oryzae*)

Description (Anon. 2011)

Adult rice weevils (GRDC 2011; Figure 23) are dark brownish black and 2–4 mm long, and have a long weevil 'snout'. They have four small light-coloured patches on their rear wing covers. They rarely fly, but climb vertical surfaces (e.g. in a glass jar). Similar species include *S. zeamais* (maize weevil) and *S. granarius* (granary weevil).

Life cycle

Adults live 2–3 months. Larvae are generally not seen—they feed and develop inside single grains. The life cycle is completed in 4 weeks at 30 °C and 15 weeks at 18 °C. Breeding stops below 15 °C.

Detection

Under warm conditions or when grain is moved, rice weevils are often observed climbing out of grain up vertical surfaces. Sieving and probe traps are recommended to detect low numbers.

Figure 24. Lesser grain borer.
Photo: R. Martin

Lesser grain borer (*Rhyzopertha dominica*)

Description

Lesser grain borer (Figure 24) is a serious pest of most stored grains and has developed resistance to a number of grain insecticides (GRDC 2011). It is a dark brown, cylindrically shaped beetle, up to 3 mm long, with club-like antennae. Viewed from the side, the beetle's mouth parts and eyes are tucked underneath the thorax. Adult beetles are strong flyers.

Life cycle

The life cycle is completed in 4 weeks at 35 °C and 7 weeks at 22 °C. Breeding stops below 18 °C. Females lay 200–400 eggs on the grain surface. Young larvae (white with brown heads) initially feed outside the grain, then bore into the grain. Adults live for 2–3 months.

Detection

The borer's habit is to remain hidden in grain. Regular sampling and sieving is required for detection.

BENEFICIAL INSECTS

A broad range of insects, as well as spiders, consume other insects or parasitise them, and reduce the number of pest insects. These predators and parasites are called beneficial insects or 'good bugs' because they do more good than harm to the crop.

Beneficial insects seek out and destroy other insects in a wide range of crops, and are an important component of natural pest control. Parasitic insects need other insects to complete their life cycle. They interfere with the pest by slowing down the build-up of pest numbers, and can prevent major outbreaks.

A healthy predator population may be effective in controlling pest insects. It could save the farmer time and money by reducing the need to apply insecticides.

The number of beneficial insects in a crop depends on the food resources available, shelter, climatic conditions and use of insecticides. Farmers should check to see whether the crop has a healthy and viable population of predators and parasites by examining the life cycle stages and numbers of these species.

Many insecticides will kill both pest and beneficial insects, although there are a few that only kill target pests. For sustainable pest management, pest control should not rely solely on chemical insecticides, but try to retain beneficial insects.

Knowing which bugs are beneficial can help farmers decide on pest control options. Some common beneficial insects found in mungbean are described below. For a more complete range, see Pol et al. (2010).

Figure 25. Six spotted ladybird adult (left), larva (centre) and pupa (right).
Photos: R. Martin

Six-spotted ladybird (*Cheilomenes sexmaculata*)

Description

Adult six-spotted ladybirds are 3–6 mm long and 3–5 mm wide. The body outline is oval and shiny, and the ground colour is orange, light red, yellow or pinkish. There are six black spots on the wing covers, including two zigzag lines and a rear black spot. Larvae are dark grey to brown, with yellowish patches. Pupae are yellow with black spots (Figure 25).

Pests attacked

Ladybirds are important predators of insect eggs and larvae of aphids, mealybugs, thrips and whitefly.

Impact

Ladybirds are good predators and eat a lot of small pest insects. They can reach large numbers and can successfully control pests in combination with other predators.

Figure 26. Transverse ladybird adult (left), pupae (centre) and larva (right).
Photos: R. Martin

Transverse ladybird (*Coccinella transversalis*)

Description

Adult transverse ladybirds are 5 mm long and bright orange–red in colour, with black markings on the back (Figure 26). There is a dark strip down the centre of the back where the wings meet, and prominent V-shaped markings on each side. These ladybirds are active during the day. Adults and larvae can be found living on the same food plants.

Pests attacked

Transverse ladybirds eat the same pest insects as six-spotted ladybird.

Figure 27. Adult *Trichopoda* (left) and small white eggs on *Nezara viridula* adult (right). Photos: R. Gunning, C. Pol

Feather-legged flies (*Trichopoda spp*.)

Description

Trichopoda is a genus of small, brightly coloured flies that range in size from 5 to 13 mm (Figure 27). The flies have a distinctive fringe on the hind legs. The eggs are laid on adult or late nymphal stages of GVB. On hatching, the maggot bores into the body of the host and feeds on the host's fluids for about 2 weeks. When fully grown, the maggot emerges, killing the host, and pupates in soil. The adult fly emerges after about 2 weeks.

Pests attacked

Trichopoda species have been released as a biological control for GVB in various parts of the world.

Impact

Parasitism rates can be as high as 50%, but there is conflicting evidence of the effectiveness of biological control by this parasitoid.

Figure 28. *Trissolcus basalis* adult ovipositing into GVB eggs. Photo: T. Smith

Pentatomid egg parasitoid (*Trissolcus basalis*).

Description

Trissolcus basalis is a very small black wasp (about 2 mm long), with downward bent antennae and a flattened abdomen (Figure 28). Wing veins are not obvious.

Pests attacked

In parts of the world where it has been released, *T. basalis* usually occurs in all crops attacked by GVB, including cotton, maize, soybean and other legumes. It lays eggs inside pentatomid eggs, where they develop to adulthood. The primary host is GVB, but *Trissolcus* also parasitises eggs of other pentatomids, including beneficial ones.

Impact

T. basalis can reduce GVB numbers by more than 50%. Planting trap crops of early-maturing soybeans could be an IPM strategy to reduce GVB numbers in the main crop.

Rats

In some districts, including Thmor Kuol and Ek Phnum, some farmers have stopped growing mungbean in the dry season because they have not been able to control rats. Rats are very difficult to control. A combination of methods, such as physical barriers around the perimeter of the field, water moats, traps and rodenticides, are required for control.

Baiting

Baiting can be done using the anticoagulant flocoumafen (Storm®).

Suitable bait locations include active rat holes, along runs and under rubbish. A barrier of bait locations is established between rat living areas and the crop. Secure three or four bait blocks at each bait location on wire or nails, or inside rat bait boxes. Also place one or two in each rat hole. Inspect the bait locations after 3 days, and select new locations where there has been no rat activity. Inspect again 4 days later and replace any blocks that have been eaten. Repeat the inspection of all bait locations at 7 day intervals, replacing fresh blocks only when blocks have been eaten and until all signs of rat activity have disappeared. Normally only three or four baiting rounds are required.

Figure 29. The rice field rat. Photo: R. Martin

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