Australian Government

Australian Centre for International Agricultural Research

SORGHUM PRODUCTION GUIDE

FOR CAMBODIAN CONDITIONS

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2015

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. ACIAR operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. It commissions collaborative research between Australian and developing-country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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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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ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
EWS	Early Wet Season
UNFCCC	United Nations Framework Convention on Climate Change

CROP DESCRIPTION

Key management tips

> Select soil that drains freely.

> Use high-quality seed and check the expiry date.

> Determine the amount of stored water in the soil profile prior to post-monsoon season sowing.

> If there is less than 80 cm of wet soil, consider not sowing sorghum.

> Use no-tillage for non-irrigated crops to prevent loss of soil water and delayed sowing.

> Apply complete NPK fertiliser plus trace elements at sowing under non-irrigated conditions as there is no opportunity for urea top-dressing in the dry season.

> Assess potential weed problems and carefully plan weed control options.

> Under dry season conditions, it is essential to apply a pre-emergence herbicide as weed control using post-emergence herbicides is likely to be difficult without rain.

> Monitor and, if necessary, control insects such as bean pod borer from budding through flowering.

> Assess the potential for rat, mice and bird damage.

Figure 1. Sorghum has been grown successfully by upland farmers in the post-monsoon season in Cambodia. Photo: R. Martin.

Grain sorghum has been successfully grown as a post-monsoon season crop in field experiments in North-West Cambodia between 2012 and 2015. It has also been successfully grown previously in the post-monsoon season by farmers in Pailin (Figure 1). Sorghum is well suited to post-monsoon season cropping as it responds very well to no-till farming systems on the friable upland Ferrosols and Vertosols of Kamrieng, Malai, Pailin, Phnum Proek, Rotonak Mondul, Samlout, and Sampov Lun, districts. For soil type descriptions, see White et al. (1997).

Grain sorghum is used for livestock feed in the beef, dairy, pork and poultry industries, as a source of both starch and protein. There is also an increasing market for human consumption and there is continued interest in sorghum as a feedstock for ethanol production.

Seasonal sowing opportunities for sorghum

Cambodia experiences a monsoonal climate with distinct wet and dry seasons (Nesbitt 1997). The wet (monsoon) season extends from May to late November and the dry season from December to April. The period from February to the beginning of May is often referred to as the early wet season (EWS) in upland cropping systems.

According to the Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) changes in temperature and rainfall in Cambodia have occurred in the second half of the 20th Century. The projection for the next 80 years is that temperatures will continue to rise, with potential declines in dry season rainfall, and delayed arrival of the wet season (Anon 2013).

The trend to hotter and drier conditions between February and May have seen more frequent crop failures in upland areas. In recognition of this trend, Montgomery (pers. comm.) has proposed that the seasons be renamed as follows:

- pre-monsoon: hot, dry with increasing humidity, low rainfall;
- monsoon: mild, high humidity, high rainfall
- post-monsoon: cool, dry with decreasing humidity, low rainfall.

Sorghum is a drought-tolerant option for planting after the harvest of monsoon season crops, in September to November. Recent research suggests that a safer upland crop planting regime is to delay planting of pre-monsoon crops from February to May, followed by a late monsoon season crop planted in October, and leaving the pre-monsoon period for soil water recharge (ACIAR project ASEM/2010/049, Stephanie Montgomery and Touch Van pers. comm.; Figure 3).

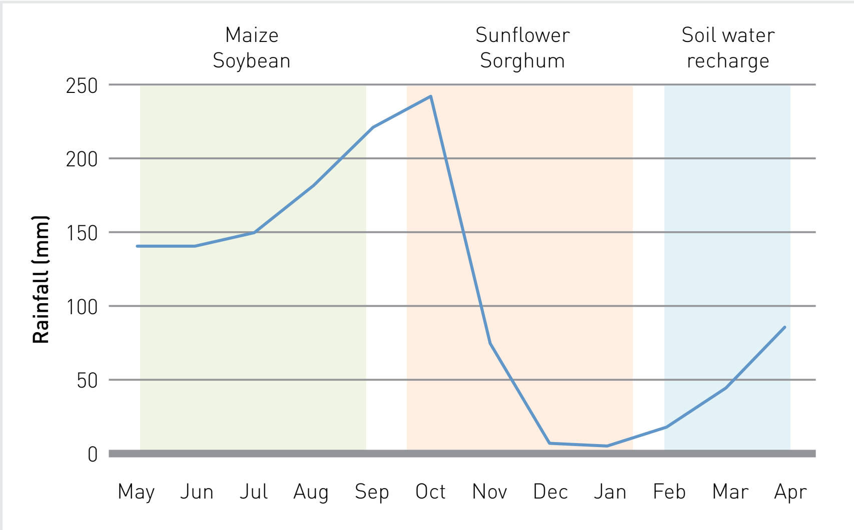


Figure 2. The best fit for sorghum in the cropping calendar for North-West Cambodia is October sowing

Yield potential of sorghum

As with sunflower (Martin et al. 2015) post-monsoon season sorghum has been successfully grown in experiments in Samlout and Pailin between 2012 and 2015. Without irrigation or rainfall after sowing, sorghum can be expected to yield 2,000-4,000 kg/ha under no-till with good weed control and agronomy. On deeper soils with good ground cover mulch and good nutrition, higher yields are possible.

Field selection

To maximise the use of residual soil water at the end of the monsoon, sorghum should be sown using no-till or minimum-tillage into the residues of the monsoon season crop and ideally after soybean to take advantage of rhizobium-fixed nitrogen (Pin et al. 2009).

No-till has been shown to be the most successful method for growing grain sorghum in North-West Cambodia and it is expected that no-till sorghum will yield at least 0.5 t/ha more than sorghum established with full land preparation. This is because no-till prevents the loss of residual soil water at the end of the wet season.

Sorghum crop residues also provide high levels of ground cover and maximise protection against soil erosion. Using no-till enables the crop to be sown after harvest of the monsoon season crop without additional rainfall. No-till can also mean the difference between planting a crop or not planting when follow-up rain is not likely to occur after land preparation.

Glyphosate should be applied, as a desiccant before harvest or after harvest of the monsoon season crop and before sowing the sorghum, to minimise loss of residual soil water.

Field history

Fields with large grass weed populations are not suited to sorghum. Sorghum is a member of the grass family and therefore in-crop chemical weed control options for grasses are limited. In contrast, broadleaf weed control options are more flexible. In particular, avoid fields infested with *Boart Salay* (*Sorghum* hybrid) and *Treng* (*S. propinquum*) as these weeds cannot be controlled by atrazine (Figure 2).

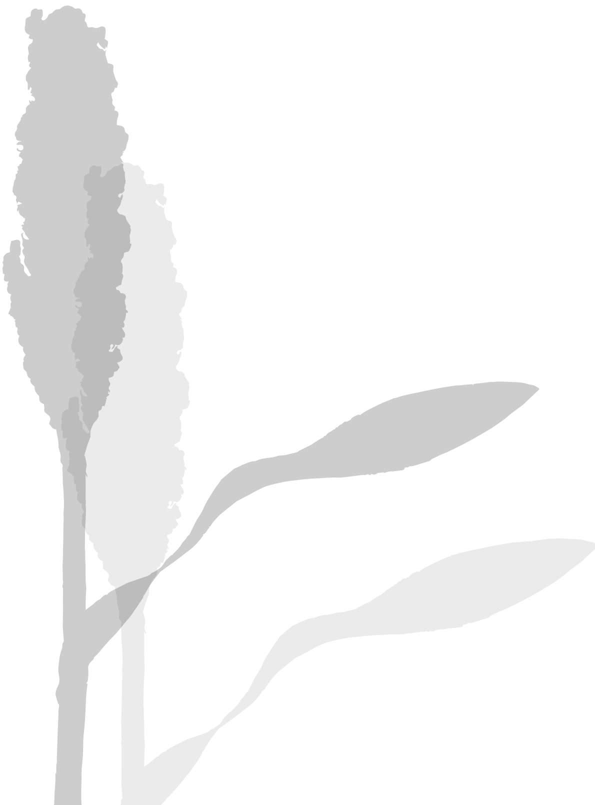
Figure 3. (a) *Sorghum* hybrid in maize

Figure 3. (b) Panicle of *S.* hybrid

Figure 3. (c) Panicle of *S. propinquum*. Photos: R. Martin.

Soil type

Planting post-monsoon season sorghum into fields with less than 1 m of wet soil reduces the likelihood of high yields and increases the risk of crop failure, as there is little likelihood of rain after November. The most suitable soil types for growing post-monsoon season sorghum are Labansiek (Ferrosol) and Kampong Siem (Vertosol).



Land preparation and planting

Residues of the previous crop should be chopped and left in the field to reduce soil surface temperature and soil water evaporation (Montgomery pers. comm.) No-till planting sorghum into crop residues at the end of the wet season is essentially a four-step process.

1. Maize stover, after hand picking, should be chopped to form a surface mulch. If a combine harvester has been used, there is no need for further chopping (Figure 4).
2. Pre-sowing herbicides should be applied immediately after chopping.
3. Planting with a no-till planter should be done approximately seven days after herbicide application (Figure 5).
4. Post-sowing pre-emergence herbicide should be applied, if required.

Figure 4. Dry season sorghum is best planted after a machine-harvested legume crop such as soybean. Photo: R. Martin

Figure 5. No-till planting into machine-harvested soybean residue. Photo: R. Martin

Row spacing and plant population

Sorghum is typically planted in 75 or 100 cm rows. However, no research on row spacing has been conducted in North-West Cambodia to confirm this. Wider row spacing and lower plant populations will reduce the risk of crop failure for post-monsoon season planting.

The target plant population depends on the depth of soil moisture at planting and the expected growing conditions. Target populations should range between 30,000 and 60,000 plants/ha depending on rainfall and available soil water. The target population for post-monsoon season sowing should be around 30,000 plants/ha.

When calculating planting rates, allow for an extra 20–25% for establishment losses when planting into a very good seedbed on heavy black soil using press wheels and 40–50% losses when seedbed conditions are fair or when press wheels are not used. Obtain the number of seeds per kilogram and the germination percentage from the bag.

To determine the planting rate (kg seed/ha):

$$\frac{\text{Required number of plants/m}^2 \times 10{,}000}{\text{Seeds/kg} \times \text{germination \%} \times \text{establishment \%}}$$

Example calculation:

$$\frac{74 \text{ (target plant population/m}^2) \times 10{,}000}{30{,}000 \text{ (seeds/kg)} \times 0.90 \text{ (germination \%)} \times 0.75 \text{ (establishment \%)}} = 1.98 \text{ kg seed/ha}$$

Crop establishment

Apart from moisture stress, the major factors that usually significantly reduce yields are poor crop establishment, poor nutrition and weed competition. The following recommendations should help to improve crop establishment and yields.

Uniform establishment and accurate depth placement of seed is essential. Precision planters achieve both of these. Planters should have tynes or discs mounted on parallelogram planter units so they independently adjust to uneven soil surfaces. Planter seed plates should be matched to seed size to ensure there are no misses or doubles/ triples on the plates.

Narrow points or discs are better suited to no-till and minimum-till conditions, and work very well in free-flowing soils but excessive planting speeds will reduce establishment.

The seed should be placed about 3–5 cm deep. Press wheels are essential, not only to improve establishment, but also to help control soil insect pests which attack germinating and emerging sorghum. Crop establishment is improved when the shape of the press wheel matches the shape of the seed trench.

Varieties

The only varieties of sorghum available in Cambodia are hybrids. These include three hybrids from Advanta-Pacific Seeds, Thailand, www.pacthai.co.th/en/product5.htm (Table 1).

Table 1. Sorghum hybrid characteristics

Characteristic	PAC89	PAC81	PAC99
Average yield (kg/ha)	5,625	5,633	5,000
Maximum yield (kg/ha)	6,875	8,243	6,950
Head type	Semi-open	Semi-open	Semi-open
Grain colour	Red	Red	Red
1,000 grain weight (g)	30-35	30-35	30-35
Plant height (cm)	130-145	124-160	145-175
Days to 50% flower	54	60	55
Days to maturity	100-105	110-120	100-105
Midge resistance	✓		
Stay green		✓	

Growth and development

Sorghum is an annual-perennial tropical grass which has a growing season of between 100 and 120 days in Cambodia. The rate of growth is strongly dependent on temperature and moisture but can also be influenced by soil fertility and insect and disease damage.

Germination and establishment

Emergence usually occurs within three to 10 days of planting. Under warm temperatures, adequate soil moisture, good seed vigour and normal sowing depth, the time taken from planting to emergence is closer to three days. Sorghum has hypocotyl emergence, where the stem below the cotyledon (seed leaf) grows and elongates, bringing the cotyledon and the growing point for all new leaves above the soil surface.

Vegetative development

Following shoot emergence, leaves will progressively unfold. The seed leaf can be easily identified as it has a rounded instead of a pointed tip. The growing point remains below ground until approximately 30 days following emergence, at which point the plant changes from vegetative to reproductive growth. The root system will grow at a rate of around 2.5 cm per day to a maximum depth of about 1.8 m.

Reproductive development

Leaves will continue to unfold until the flag leaf has emerged. At this point, around 80% of the total leaf area has developed. The head will form within the flag leaf sheath and continue to be pushed upwards until becoming visible. Flowering begins at the top of the head and moves downwards over a period of four to five days.

Once pollination has occurred, seeds will begin to form, taking around 30 days to reach full development. Visually, the seeds become rounded, up to around 4 mm in size and then start to change colour. The final colour varies from white through to red or brown in most sorghum hybrids.

Physiological maturity to harvest

The grain is said to be physiologically mature when a black spot appears at the point where the seed attaches to the plant. At this stage, the seed is fully mature and will not gain any more nutrients or moisture from the plant. The moisture content is usually around 30% at this time.

If using a desiccant, this is the optimum time to apply a registered herbicide to kill the plant to bring forward harvest and to prevent additional soil water use.

The length of time between physiological maturity and harvest depends on a number of factors, including whether a desiccant is used and on environmental conditions, such as temperature.

Nutrition

Nitrogen

Of all the nutrients, sorghum is most responsive to the application of nitrogen (N). However, the maximum response to N will not result, even in soils known to be deficient, if concentrations of other nutrients such as phosphorus (P), potassium (K) and sulphur (S) are limiting. Therefore, it may prove uneconomical to apply N without prior knowledge of the concentrations of other major nutrients within the soil.

For post-monsoon season planting, N is best applied either pre-planting or at the time of sowing. This is because the opportunity to apply N within the post-monsoon season is not guaranteed as rainfall events are unlikely, especially in December and January. Should the opportunity arise, N may be applied to sorghum post-emergence up to the seven-leaf stage and still contribute positively to yield as opposed to grain protein. If N application is delayed beyond this point, a greater proportion ends up contributing to grain protein and not yield.

Rates of 100–150 kg/ha of N can be applied to high-yield potential crops. N could represent a large proportion of input costs however its use is justified because of the expected return on investment. Sorghum planted after a well-nodulated legume crop, such as soybean, will require less N fertiliser. For more information on responses of legume crops to rhizobium inoculation, see Pin et al. (2009).

The contribution of a legume crop to soil N largely depends on the quantity of dry matter produced and levels of nodulation. However, as a guide, compared with a previous maize crop, cowpea and mungbean crops may leave up to 40 kg/ha of soil N, while soybean and pigeon pea may leave 25–50 kg N/ha.

N budgeting can be used to determine the N requirements of a crop and can be calculated using the formula below. The quantity of N required to grow the crop is about twice the quantity removed in the grain.

N removed in grain (kg/ha):

Target yield (t/ha) × grain protein % × 1.6 (conversion factor)

N required for crop (kg/ha):

N removed in grain × 2 (N-use efficiency)

Example calculation:
(3 (t/ha target yield) × 10 (% grain protein) × 1.6 (conversion))
× 2 (efficiency)
= 96 kg/ha

N uptake by a crop comes from the available soil nitrate N and from fertiliser N. Soil nitrate N can be estimated by soil testing and from the cropping history, especially the grain yield and protein content of the previous crop. Some additional N will be mineralised from organic matter throughout the growing season and available for uptake by the crop.

Once the N requirement for a crop is known, the amount of N that already exists within the soil may then be subtracted to generate an estimation of the quantity of N that must be applied as fertiliser to produce a crop with the target grain protein content and yield.

Using the above example, if only 50 kg/ha of nitrate N was available in the soil, then a further 46 kg N/ha (100 kg urea/ha) would be needed for a 3 t/ha crop.

The protein content of grain is a good indicator of the adequacy of N supply to a crop. Maximum yield is thought to be achieved when grain protein content is between 9–10%. At lower protein readings, the crop is considered to have been N deficient whilst at higher readings, crop N availability is considered excessive.

Phosphorus

Sorghum is efficient at extracting phosphorus (P) from the soil profile compared to some other crops. However, based on observations of maize crops, P deficiency appears to be common in the soils of North-West Cambodia. Laboratory testing of soil for P will identify soils with insufficient reserves to meet crop demands. P deficiency is indicated by dark green leaves with reddish-purple tips and leaf margins. It is more likely to appear in young plants (Figure 6).

Figure 6. Phosphorus deficiency in maize. Photo: R. Martin

Zinc

Both sorghum and maize are sensitive to Zinc (Zn) deficiency which affects elongation of internodes and results in stunted growth. Zn deficiency symptoms appear two to three weeks after seedling emergence. White or yellow streaks appear on each side of the mid rib extending from the base. The mid-rib and leaf margins remain green (Kumar and Sharma, 2013).

Sorghum is likely to respond to Zn on some *Kampong Siem* (Vertosols) of limestone origin. Zn deficiency is likely to occur where soil pH is greater than 7.5. Basal fertilisers such as 20:20:15 + TE (trace elements) should be used if Zn deficiency is expected. For longer term responses lasting five to six years, zinc oxide should be applied at approximately 15 kg/ha and incorporated into the seedbed well before sowing. Foliar sprays are also a popular option for applying Zn.

Weed management

Figure 7. Without good weed control, crops can be completely overrun by weeds in Cambodian upland conditions

Weed management tips

- Where possible, plant post-monsoon season sorghum after a broadleaf crop such as soybean to take advantage of rhizobium-fixed N.
- Pre-emergence weed control is essential as post-emergence herbicides are not likely to work on water-stressed weeds in the post-monsoon season.
- Avoid fields that are infested with grass weeds, especially Boart Salay (*Sorghum* hybrid) or Treng (*S. propinquum*).
- Control weeds, especially those that reproduce vegetatively, before sowing.
- Use a post-sowing, pre-emergence herbicide as a priority.
- Prevent weeds from setting seed during the crop cycle and post-harvest.

Integrated weed management

In the upland situation in Cambodia, water is often the most critical factor for reducing potential crop yield. Crops can fail because of heat and drought, especially in the pre-monsoon season when rainfall is variable and unreliable. Good weed control is essential under these conditions, especially before sowing, to avoid the depletion of subsoil water by competing weeds (Figure 7).

Significant yield losses occur if weeds are not controlled in sorghum immediately after planting. For post-monsoon crops, pre-sowing or post-sowing pre-emergence weed control is essential. Post-emergence herbicide applications have been shown to be ineffective because weeds are water-stressed in the dry conditions (Martin et al. 2015).

Farmers are encouraged to use an integrated weed management approach that combines all available options. The aim should be to keep weed numbers low and prevent weeds from producing seeds throughout the cropping cycle.

Weeds commonly occurring in upland crops in Cambodia are described by Martin and Pol (2009). Special attention should be given to controlling weeds before the crop is sown. This means preventing weeds from setting seeds in the previous crop and controlling weeds around the edge of the field, along waterways and in adjacent non-cropped areas. Special attention also needs to be given to weeds that regrow from stolons, rhizomes, underground tubers or bulbs (Appendix 1). These weeds are difficult to control by cultivation and regrow from cut plant parts after the crop is sown.

Chemical weed control options

Farmers in Cambodia are either unaware, or choose not to use pre-planting or post-sowing pre-emergence herbicides. Local trials with maize, mungbean and sunflower have shown that pre-emergence herbicide applications are much more effective than post-emergence application. Herbicide options for sorghum are given in Table 2.

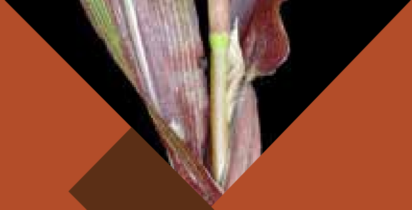
For effective control of most weeds, apply atrazine either before planting, at planting or immediately after planting. Where *Sorghum* weeds are present, s-metolachlor can be applied as a post-sowing pre-emergence alternative to atrazine, provided that the sorghum seed has been treated with ConcepII® seed safener.

Herbicides can be used for weed control in sorghum pre-sowing, post-sowing pre-emergence and post-sowing (Appendix 1). Replacing the final cultivation with a herbicide application reduces the number of weeds emerging with the crop and 33% of farmers in Pailin province have adopted this practice (Touch et al. 2013). This is also the time to control perennial or vegetatively reproducing weeds.

Table 2. Herbicides registered in Cambodia that can be used in sorghum

Active ingredient	Group	Pre-plant	Post plant pre-em	Post-em	Harvest desiccation
2,4-D	I	✓		✓	
Atrazine	C	✓	✓	✓	
Glyphosate	M	✓			✓
S-metolachlor*	K		✓		
Fluroxypyr	I			✓	

* Seed for sowing must have been treated with ConcepII®



DISEASES

Disease management tips

- Include cereal crops in the rotation (e.g. rice, maize).
- Make sure seed for planting is coated with fungicide.
- Prevent damage from insects, birds and rodents that can provide entry of pathogens into the plant.
- Avoid stresses to the crop, such as water stress or too much fertiliser.
- Control weeds as weeds are alternative hosts for many diseases.
- Apply fungicide if appropriate.

Since sorghum is a minor crop in Cambodia, little is known about potential diseases. However, experience from Thailand suggests the potential for the following diseases of sorghum to occur.

Figure 8. Sorghum head smut (*Sporisorium reilianum*). Photo: PaDIL, www.padil.gov.au/aus-smuts/pest/main/140149/39496#

Smuts

Description

Smuts are spore-filled galls which occur on leaves or seed heads (Figure 8). They are spread by wind, rain and with infected plant material. A number of smut diseases, caused by different fungi, occur on sorghum:

- covered kernel smut (*Sporisorium sorghi*)
- loose kernel smut (*Sporisorium cruentum*)
- head smut (*Sphacelotheca reiliana*).

Management

Kernel smuts can be controlled by fungicide seed treatments whilst head smut may be controlled by growing resistant varieties. Patterns of smut incidence, severity and distribution vary in different regions. Smuts can be economically important and could be a major biotic constraint to achieving high sorghum yields.

Figure 9. Maize leaf blight. (*Setosphaeria turcica*). Photo: CIMMYT, http://maizedoctor.org/turcicum-leaf-blight

Maize leaf blight (*Setosphaeria turcica*)

Maize leaf blight is widely distributed around the world and is hosted by a wide range of tropical grass species (Figure 9). The source of the information below is: www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=49783

Symptoms

Initially, small, water-soaked spots appear on leaves then elliptical brown areas develop until they are nearly as wide as the leaf. In the final stages, lesions are straw-coloured to grey, coalescing and they kill large parts of the leaves. The margin is tan on maize and red-purple on sorghum, depending on the variety. Infection on maize may include tassels, ears, crowns and seedlings.

Symptoms on resistant cultivars are reduced to small chlorotic or necrotic spots.

Management

Rotation with non-grass crops and elimination of weedy grass hosts are recommended. The major thrust of disease control has been through breeding resistant cultivars.

Figure 10. Leaf rust (*Puccinia sorghi*). Photo: CIMMYT, http://maizedoctor.org/common-rust

Leaf rust (*Puccinia purpurea*)

Leaf rust can be a serious disease in susceptible hybrids under humid conditions.

Symptoms

Leaf rust appears as small reddish-brown spots on the leaves (Figure 10). As they develop, the pustules become raised and release a powdery spore.

Conditions favouring development

The spores germinate on wet leaves, penetrating the leaf and then taking around 10 to 14 days for the pustules to appear. The spores are primarily dispersed by wind. Little is known about the fungus but suggestions are that the rust is more likely to occur in cool wet conditions.

Management

Sorghum sown in October to November will experience moist conditions during the first four to six weeks after sowing but dry conditions thereafter. Therefore rust might not present a significant threat later in the crop. Choose a rust-resistant variety if available.

Figure 11. Sorghum ergot (*Claviceps africana*). Photo: DAF QLD, www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/sorghum/disease-management

Sorghum ergot (*Claviceps africana*)

Sorghum ergot is a fungus whose spores compete with pollen at flowering. Ergots are creamy-coloured sclerotes usually smaller than sorghum seed that replace the developing seed (Figure 11).

Conditions favouring development

Sorghum ergot infects sorghum heads at flowering and is favoured by mild temperatures (15–30°C) high humidity and overcast conditions. Ergot spores compete with pollen in the unfertilised florets, decreasing grain set and potential yield.

Management

Sorghum planted in October to November will flower in December to January when conditions are drier. Under these conditions, the risk of ergot infection is lower. Sorghum ergot can cause harvest delays with the sticky honeydew clogging machinery. At levels higher than 0.3% by weight, the fungus is toxic to livestock.

INSECT PESTS

Insect management tips

- > Keep weeds under control between crop plantings.
- > Make sure seed for planting is coated with insecticide.
- > Carefully check for insect pests before applying insecticide.
- > Avoid application of broad spectrum insecticides in the vegetative stage to preserve beneficial insects.
- > Control weeds as weeds are alternative hosts for many insects.
- > Apply insecticide if thresholds are reached.

The common insect pests and beneficial organisms for upland crops in Cambodia are described in Pol et al. (2010). As sorghum is a minor crop in Cambodia, little is known about the potential insect pest problems that could emerge.

Figure 12. The corn aphid (*Rhopalosiphon maidis*)

Corn aphid (*Rhopalosiphon maidis*)

Aphids

The most likely aphid species to be found in sorghum in North-West Cambodia are the corn aphid (*Rhopalosiphon maidis*) and the sugarcane aphid (*Melanaphis sacchari*). Aphids frequently infest sorghum heads towards the end of grain fill, however there is usually minimal economic damage, even when conditions are dry. Under extremely high populations, they may affect yield and quality.

Description

Adults are up to 2 mm long and light to dark olive-green in colour, with a purple area at the base of small, tube-like projections at the rear end (Figure 12). They are usually wingless. Antennae extend to about one-third of the body length. Nymphs are similar but smaller in size.

Damage

Adults and nymphs suck sap and produce honeydew. Very high numbers may turn plants yellow. High populations on the fruit heads produce sticky grain. A combination of aphid attack and water stress can cause reduced crop yield. All stages of the crop are attacked but the most serious damage is when high numbers occur during the reproductive phase.

Figure 13. Bean pod borer (*Helicoverpa armigera*): (a) larva; (b) adult. Photos: W. Leedham

Bean pod borer (*Helicoverpa armigera*)

Damage

The bean pod borer (Figure 13) can attack sorghum both in the vegetative and reproductive phases. It is only when they attack developing grain that control may be warranted. Checking for bean pod borer should be done very early in the morning or very late in the evening twice a week. Aim to control larvae before they reach 7 mm in length as larger larvae cause more damage and are harder to control.

Management

Eggs are laid between head emergence and flowering. Spray application at three days after 50% of the crop has brown anthers to the base of heads is ideal.

Figure 14. Sorghum midge (*Contarinia sorghicola*). Photo: DAF QLD, www.daf.qld.gov.au

Sorghum midge (*Contarinia sorghicola*)

The sorghum midge is a fly, the adult male is approximately 1.3 mm in length and the female 1.6 mm (Figure 14).

Damage

Sorghum midge can severely reduce yields but to what extent in Cambodia is not known.

Management

During head emergence and flowering, crops should be checked daily about three to four hours after sunrise. Plant the slowest hybrid first and ensure an even establishment. Damage to crops can be significantly reduced by planting a hybrid with resistance. Use of synthetic pyrethroids for midge control can lead to increased aphid populations which can create harvest problems. Midges are very mobile and so re-infestation of crops is common.

Desiccation

Desiccation of sorghum is used to reduce the time to harvest, controls late season weeds and start the fallow to store more soil moisture. It effectively reduces late season transpiration losses such that soil moisture may be conserved for use by the subsequent crop or for earlier commencement of the fallow period.

A pre-harvest spray of glyphosate can be applied immediately after physiological maturity has been reached. This will hasten dry down of the grain and should kill or desiccate the crop. Desiccation allows crops to be harvested earlier and more efficiently than if crops are not sprayed.

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Appendix 1. Herbicide options for weed control in sorghum

Khmer name	Scientific name	Type	Pre-sowing			Post-sowing pre-emergence			Post emergence		
			Atra-zine	Glypho-sate	2,4-D	Ala-chlor	Atra-zine	S-metol-achlor	2,4-D2	Atra-zine	Flurox-ypyr
Kravanh Chruk	*Cyperus rotundus**	Sedge		✓							
Smao Ko	*Brachiaria reptans*	Grass		✓		✓		✓			
Smao Chenh Chean	*Cynodon dactylon**	Grass		✓							
Smao Cheung Kras	*Dactyloctenium aegyptium*	Grass		✓							
Smao Sambok Mon	*Digitaria spp.*	Grass	✓	✓		✓	✓	✓		✓	
Smao Bek Kbal	*Echinochloa colona*	Grass	✓	✓		✓	✓	✓		✓	
Smao Samsorng	*Eleusine indica*	Grass	✓	✓		✓	✓	✓		✓	
Sbauv Klang	*Imperata cylindrica**	Grass		✓							
	Leptochloa chinensis	Grass									
	*Melinis repens**	Grass		✓							
Boart Salay	*Sorghum bicolor*	Grass		✓			✓			✓	
Treng	*Sorghum halepense**	Grass		✓			✓			✓	
Kantraing Kath	*Ageratum conzoides*	Broadleaf	✓	✓	✓		✓	✓	✓	✓	✓
Phti Banla	*Amaranthus spinosus*	Broadleaf	✓	✓	✓	✓	✓	✓	✓	✓	✓
Phti Daung	*Amaranthus viridus*	Broadleaf	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Bidens pilosa	Broadleaf		✓	✓			✓	✓		✓
Phti Thmar	*Boerhavia diffusa**	Broadleaf			✓				✓		
Maam Phnom	*Borreria alata*	Broadleaf	✓				✓	✓		✓	
Kos Ambeng	*Cardiospermum halicacabum*	Broadleaf									
Slab Tea	*Comellina benghalensis**	Broadleaf		?	✓			✓	✓		✓
	Crassocephalum crepidioides	Broadleaf	✓	✓	✓		✓		✓	✓	

Changkrang Svar	*Crotalaria pallida*	Broadleaf	✓	✓			✓			✓	
Mok Chhneang	*Eclipta prostrata*	Broadleaf									
Tuk Das Khla Thom	*Euphorbia heterophylla*	Broadleaf									
Sandar Chhou	*Ipomoea triloba*	Broadleaf	✓		✓		✓		✓	✓	✓
Voir Mouy Lib	*Ipomoea obscura*	Broadleaf	✓		✓		✓		✓	✓	✓
Phreah Khlob Damrei	*Mimosa invisa**	Broadleaf	✓				✓			✓	✓
Phreah Khlob	*Mimosa pudica**	Broadleaf									✓
Sav Mao Prey	*Passiflora foeteda**	Broadleaf	✓	✓			✓	✓		✓	✓
Pang Pos Srom	*Physalis angulata*	Broadleaf	✓	✓			✓			✓	✓
Kambet Chun	*Portulaca oleracea*	Broadleaf	✓	✓	✓	✓	✓	✓(S)**	✓	✓	✓
	Richardia brasiliensis	Broadleaf									
Kantraing Bay Sar Nhi	*Sida acuta*	Broadleaf	✓	✓			✓			✓	✓
Kantraing Bay Sar	*Sida rhombifolia*	Broadleaf	✓	✓			✓			✓	✓
	Solanum nigrum	Broadleaf	✓		✓	✓	✓	✓	✓	✓	✓
Smao Krab Sa-eth	*Stachytarpheta indica*	Broadleaf			✓				✓		✓
Chung Kong Proes	*Trianthema portulacastrum*	Broadleaf	✓	✓	✓		✓	✓	✓	✓	✓
	Tribulus terrestris	Broadleaf		✓	✓	✓		✓	✓		✓
	*Tridax procumbens**	Broadleaf			✓				✓		

* Perennial or reproduces vegetatively. ** S = suppression.

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