

# Mungbean (*Vigna radiata* (L.) R. Wilczek) varietal evaluation for northwest Cambodian lowland rice systems

Harry E.G. Campbell-Ross<sup>1</sup>, Sophea Yous<sup>2</sup>, Robert J. Martin<sup>1</sup> and Daniel K.Y. Tan<sup>1</sup>

<sup>1</sup>The University of Sydney, Sydney Institute of Agriculture, School of Life and Environmental Sciences, Faculty of Science, Sydney, NSW, Australia

<sup>2</sup>The University of Battambang, Battambang Province, Cambodia

## Abstract

Small-scale agriculture is the economic, social and cultural bedrock of Cambodian rural communities. Crop diversification is not widespread in these traditionally rice-producing smallholder farms. Rice monoculture has led to a decline in farm productivity and farming household income. Mungbean is emerging as a high-value opportunity for crop diversification in smallholder farms in north-west Cambodia praised for its favourable agronomic qualities. However, its expansion is being constrained by the low quality of varieties available to farmers. This study aims to evaluate the locally available varieties with others from Cambodia and the region by comparing the varieties' agronomic and economic characteristics. The varieties from Cambodia, CMB-3 and CARDI-Chey, had superior agronomic and quality characteristics compared with the varieties available to farmers. This was reflected in the price estimate and income of both varieties which had the highest gross margins. Hence, the varieties currently available to farmers are unsuitable for continued cultivation in the modern mungbean production environment.

**Keywords:** Mungbean production, Cambodian Agriculture, Variety Evaluation, Smallholder farming, Pulse Production

## Introduction.

Small-scale agriculture is the mainstay of most rural economies in the developing world. The dry-season growing period, typically left as fallow, can be utilised by cultivating drought tolerant crops such as mungbean on the residual soil moisture and with some supplementary irrigation where available (Touch *et al.* 2017). Mungbean (*Vigna radiata* (L.) R. Wilczek) is favoured by farmers as a dry-season crop choice due to its short growing duration and high price during the dry season (Fukai and Ouk, 2013). As with most pulses, mungbean is susceptible to fungal infection and insect pest infestation. Thus maintaining a consistent plant density through mechanically sowing seed, in place of hand broadcasting, is critical to minimising the risk of infection (Martin *et al.* 2016). The beneficial effects of mungbean are compounded as a direct link between pulse production and an increase in the subsequent season's rice yield has been identified in a number of lowland rice system studies (Singh *et al.* 2005; Bastia *et al.* 2008; Kaewpradit *et al.* 2009; Ali *et al.* 2012). The decision to produce a dry-season mungbean crop is supported by the current trend of a relatively high mungbean farmgate price due to an increase in global, particularly Asian, demand for mungbean and other pulses (Rao *et al.* 2010; Nair *et al.* 2013). This is because mungbean is a cheap and accessible source of protein, iron and micronutrients (Keatinge *et al.* 2011).

The most concerning agronomic constraint to mungbean production is the chronic soil compaction present in most lowland rice fields (Mitchell *et al.* 2013). Additionally, it is common for the soil to lack porosity, organic matter, and bioavailable macro- and micronutrients. The abiotic stressors exacerbate the biotic pressures such as pest infestation, weed competition and disease. The economically significant pests to mungbeans in lowland rice systems are: powdery mildew (*Microsphaera diffusa*), legume pod-borer (*Maruca vitrata*), and the cotton bollworm (*Helicoverpa armigera*) (Gahukar and Reddy 2018). Martin *et al.* (2016) also highlighted that weeds such as goatweed (*Ageratum conyzoides*) can spread and harbour diseases like MYMV and hence, appropriate weed control is imperative for successful mungbean production.

Previous research into the performance of the available mungbean varieties, such as Ouk *et al.* (2009), concluded that the variety favoured by farmers is not the most productive nor the most resilient. Moreover, when other varieties were trialled, and the data presented to the farmers, uptake of the new varieties was quick and widespread. Our hypothesis is that the Cambodian varieties will perform better both agronomically and economically than the current Vietnamese and Thai varieties. The aim of this study is to assess the agronomic and economic characteristics of mungbean varieties in northwest Cambodia, sourced locally and throughout SE Asia for productivity, resilience and quality.

## Materials and Methods.

### *Experimental design and location.*

Replicated experiments were carried out at two field sites in Battambang Province, Cambodia. The first was a field block on the University of Battambang (UBB) site with supplementary irrigation (13°05'05" N; 103°13'11" E) and the second was at the Don Bosco School (DBS) site with no supplementary irrigation (13°04'37" N; 103°10'24" E). Ten varieties were sourced from local agricultural supply shops, government institutions or breeding institutions throughout SE Asia. The soil type at both sites was the clay-rich Toul Samrong (Alfisol). The experimental design was a randomised, complete, block design (RCBD) with four replicates in both field sites. The plots were 1.8 m by 6 m with the mungbean planted in six rows, 30 cm apart with 25 cm between hills. Prior to sowing, a liquid rhizobial inoculant containing *Bradyrhizobium* spp. was used to inoculate the seed at 100 mL/5 kg of mungbean seed. Seeds were planted at three per hill giving a target planting density of 400,000 plants/ha or 40 plants/m<sup>2</sup>. Assuming the average of 17,300 seeds/kg, this is equivalent to a seeding rate of 23.1 kg/ha. A drip irrigation system was set up at the UBB site to replace transpiration losses with a single line for each row with a basal fertiliser applied immediately after sowing.

### *Measuring the agronomic characteristics.*

The agronomic characteristics measured were emergence rate, commencement of flowering (DAS), lodging incidence, NDVI, pest, disease and weeds incidence, plant height at harvest (DAS) and final yield. Crop pests were controlled in accordance with integrated pest management (IPM) principles. The stages of mungbean growth were measured using the mungbean identification system (Pookpakdi *et al.* 1992). Due to a lack of synchronisation of maturity and the absence of desiccation, three harvests based on maturity were required to achieve the greatest yield potential.

### *Measuring the economic characteristics and statistical analyses*

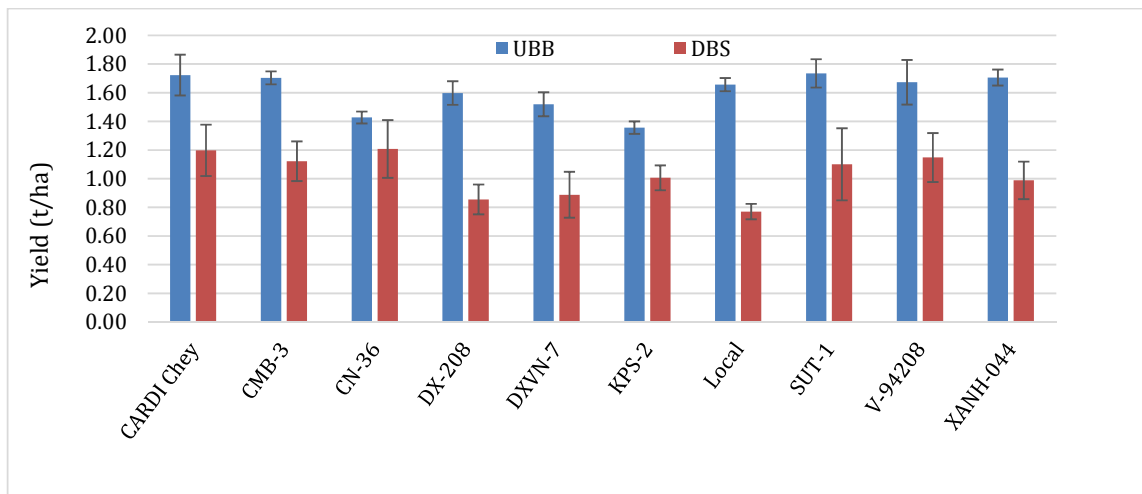
The economic characteristics are the parameters that constitute quality and therefore contribute to the price given by traders. The seed quality of each variety was assessed by four separate groups, each comprising of key farmers from the area and mungbean traders. Each variety, from both sites, was assessed on: seed size, and the quality characteristics: consistency of colour, shape and size, coat lustre, and proportion of broken seed and from this, the price estimate (in riels/kg) and net income (yield \* price). These elements were measured by different parties by visually assessing and interacting with the harvested seed; this method is subjective and based on each party's personal judgement of quality. Yet, as this is the method used in reality when traders are determining price on-farm, it was deemed acceptable. An analysis of variance (ANOVA) was used to determine significance for the varietal evaluation using Genstat and SAS JMP. The Least Significant Difference (LSD) at the 5% level was calculated for significance testing.

## Results and Discussion

### *Varietal agronomic performance characteristics*

The agronomic characteristics analysis was conclusive in its assessment of the selected varieties with both Cambodian varieties; CMB-3 and CARDI-Chey performed well for all of the parameters tested. The average emergence rates for both sites was above 95% for most varieties except for CN-36 (84%) and SUT-1 (89%). The only concerning observation was the slight degree of lodging in both Cambodian varieties at UBB. The varieties that performed poorest were two of the Vietnamese varieties; DXVN-7 and DX-208 achieved the lowest estimated price at DBS and UBB, respectively. This is likely due to both DXVN-7 and DX-208 having the lowest combined seed quality characteristics. Site location (and hence, water availability) had a significant effect on yield with all varieties producing higher yields under the adequate water conditions at UBB. This was expected as normal dry season conditions at DBS were unlikely to provide adequate soil moisture. For machine harvesting, uniformity of plant height is crucial to limit harvest losses (Martin *et al.* 2016). As the standard deviation for plant height is low, it can be inferred that all varieties had satisfactory height uniformity to allow for effective mechanical harvest. The most significant biotic constraint to mungbean production in this variety evaluation was the insect pressure present at both sites, specifically from lepidopteran larvae. The most significant pest species was the legume pod borer (*Maruca vitrata*) which caused considerable flower abortion and green pod loss. This damage was severe enough, especially at the wetter UBB site, to warrant chemical intervention by application of the lepidopteran-specific insecticide *Emamectin*. Disease control was not required at both sites as the only disease of any significance was powdery mildew (*Erysiphe polygoni*). Yet it was only present at a level below economic threshold, with only the lower leaves in the canopy having the most severe infection. Site had a significant effect on vegetative biomass but variety showed no effect. As stress induces early flowering, site had a significant effect on the commencement of flowering for all varieties

consistent with the literature (Ranawake *et al.* 2011). The varieties with the highest grain yield/ha across both sites were CMB-3, CARDI-Chey, SUT-1 and V-94208 (Figure 1).



**Figure 1.** Mean yield for both the irrigated (UBB) and non-irrigated (DBS) field experiments (error bars represent standard deviation of the mean)

#### Economic analysis

Variety had the greatest influence on economic characteristics with CMB-3, XANH-044 and CARDI-Chey producing the most desirable grain and DX-208 and DXVN-7 producing the least desirable grain (see Fig. 2). For mungbean production in SE Asia, the physical appearance is used to infer overall quality with certain traits, with shiny seed coating and green seed colour being favoured in SE Asia (Yimram *et al.* 2009). Our data are contiguous with this as the CMB-3 and CARDI-Chey varieties were rated highest for seed quality characteristics with both achieving the highest score (3.30/5) for coat lustre. Income is the main driver behind the variety and cropping rotation analysis with studies regularly measuring profitability as the ultimate benchmark in gauging success (Montgomery *et al.* 2016; 2017). Income integrates the productivity, resilience and quality characteristics to give a visual representation of each variety's complete performance over the entire variety evaluation. Successful expansion of mungbean production in north-western Cambodia relies on the knowledge of the financial incentive that mungbean production brings. This will occur through the dissemination of the information and resources gathered in this report along with other production material, such as Martin *et al.*'s (2016) production guide, in an accessible format. Both UBB and DBS sites achieved a positive net income of US \$803.33/ha and US \$217.38/ha, respectively with the high yielding varieties being CMB-3, CARDI-Chey, SUT-1 and V-94208 (Figure 2).

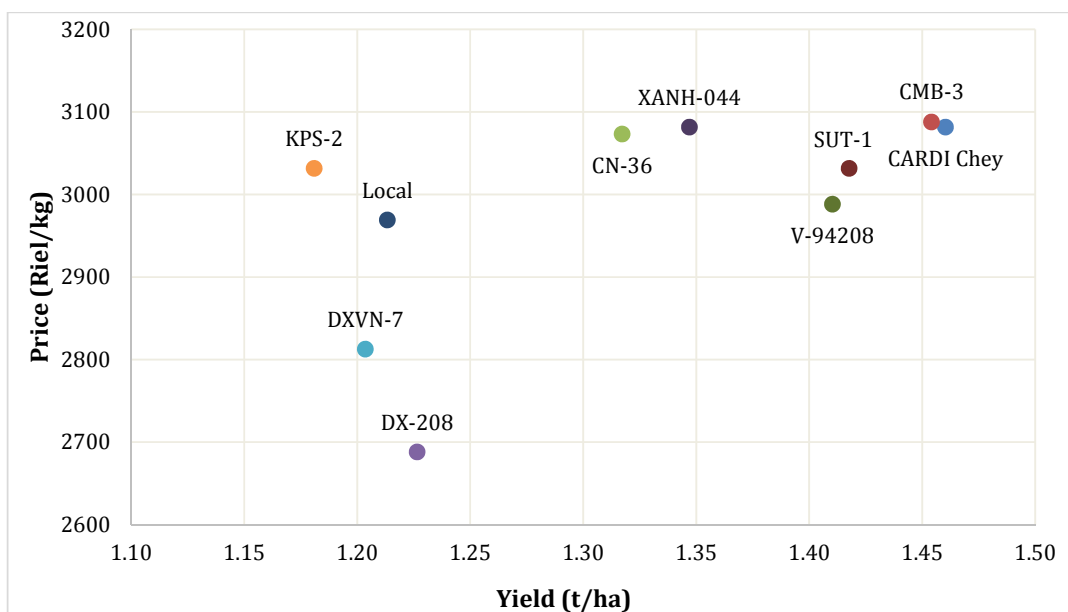


Figure 2. The relationship between average yield (t/ha) across both sites (UBB and DBS) against estimated price (Riel/kg) showing expected gross income per variety. Note: 4000 Riel = US \$1

## Conclusions

Mungbean is an emerging high-value field crop in northwest Cambodia that can be grown effectively in lowland rice systems after the wet-season rice has been harvested. However, the varieties available to farmers are unproductive and produce poor quality grain, restricting the expansion of mungbean production in this region. This variety evaluation showed that the Cambodian varieties, CARDI-Chey and CMB-3, had the most favourable agronomic and economic characteristics compared with the Vietnamese and Thai varieties. They had the highest yields, productive germination and establishment rates, and the most favourable quality characteristics. Site (water availability) had the most significant main effect on the agronomic characteristics.

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