Present Status and Future Perspectives of *Glycine* and *Vigna* in Thailand

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Abstract

Thailand has no wild *Glycine* but a number of wild species in the genus *Vigna* Sub-genus *Ceratotropis*. Soybean (*G. max*), mungbean (*V. radiata*), black gram (*V. mungo*) and rice bean (*V. umbellata*) are the main *Glycine* and *Vigna* crops in Thailand. They are a major component of cropping systems in Thailand and are grown after rice or other field crops. Although the area planted to these crops were reduced by almost 3 fold during the past 15-20 years, the crops are still considered economically and socially important. Thailand imports soybean seed, cake and meal of over 3 Mt annually but exports 20,000 t of vegetable soybean pods. There is a possibility to boost soybean production in Myanmar using Thai cultivars/breeding lines. The surplus product, if any, can be exported to many Asian countries. Some 15 soybean cultivars have been released so far by Chiang Mai Field Crops Research Center (CMFCRC), Khon Kaen University and Kasetsart University (KU) but currently "Chiang Mai 60" from CMFCRC (released in 1987) is still dominating the growing areas. Breeding soybean in Thailand has been based mainly on conventional methods. Locating of rust resistance gene and genes conferring different levels of fatty acids by KU should open the possibility of using marker-assisted selection (MAS) to improve this crop.

Thailand used to be the world's largest exporter of *Vigna* during the 1960s to 1990s, but currently lost its position to China, Myanmar and Vietnam. For mungbean, the most popular cultivars grown by farmers are "Kamphaeng Saen 1", "Kamphaeng Saen 2", "Chai Nat 36" and "Chai Nat 72". These cultivars are still susceptible to Cercospora leaf spot, powdery mildew and mungbean yellow mosaic virus diseases. The genes controlling resistance to these diseases are being tagged by SSR markers, with the hope of using them in MAS in the future. KU breeders are also working on hybrid mungbean to explore the possibility of breaking the yield barrier of the currently used pure line cultivars. For black gram, Chai Nat Field Crop Research Center is the only institution breeding black gram in Thailand. The recently released cultivar "Chai Nat 80" was found to out yield the old cultivar "Phitsanulok 2". There has been no breeding project for rice bean, however.

Introduction

Two major genera of food legumes grown in Thailand are *Glycine* and *Vigna*. *Glycine max* (soybean) is the only economically important *Glycine* sp. in the world. In Thailand, 2 types of soybean are cultivated, viz. grain and vegetable. Although Thailand annually imports over 3 Mt of soybean grain, meal and cake for the oil and feed industry. The area grown to grain soybean has been declining from over 500,000 ha to less than 150,000 ha per annum during the past 15-20 years. The area planted to vegetable soybean is rather stable at around 15,000 ha for both domestic consumption and export. Among the *Vigna* spp., the major one is mungbean (*V. radiata*) which occupied the annual planted area of some 500,000 ha during 1990s. The crop is currently sown to 200,000 ha per annum and decreasing. The main reasons for the reduction in food legume production are the expansion of residential areas and the promotion of competitive crops, especially sugarcane, corn and cassava. The other major *Vigna* spp. grown in Thailand are black gram (*V. mungo*) and rice bean (*V. umbellata*) (http://ssnet.doae.go.th, 2009).

Production of soybean in Thailand

Both grain and vegetable soybeans are grown mainly in the northern and northeastern parts of Thailand. The major production provinces are Chiang Mai, Phrae, Chaiyaphum, Loei and Mae Hong Son. Grain soybean is grown all year-round which may be grouped into 3 seasons - early rainy, late rainy and dry seasons. For vegetable soybean, there are still 2 types. The first type is grown year-round all over the country for local consumption, using mainly grain type cultivars and harvested at around R6 to R7 stages. Another type is grown during the cool season (November to March), for export to Japan when the temperature is too cold for the production in East Asian countries. The cultivars grown for export are mainly introduced from Japan to satisfy with the Japanese markets. Major production area of this high value vegetable type is in the upper north-

ern provinces where some 4-5 frozen factories are located (Sopa *et al*., 2009).

Sarobol *et al*. (2008) reported that improved soybean cultivars from Thailand were higher yielding than most, if not all, Myanmar cultivars when tested in over 30 locations in Myanmar during 2005-2007. This opens an opportunity to promote soybean production in Myanmar using Thai cultivars in the future.

Breeding of soybean in Thailand

a. Breeding of field soybean

Sopa *et al*. (2009) wrote a comprehensive review of soybean breeding in Thailand with the emphasis on the activities of Chiang Mai Field Crops Research Center (CMFCRC) of the Department of Agriculture (DOA), Ministry of Agriculture and Cooperatives. CMFCRC has been assigned a mandate of breeding soybean during the past 50 years. The first batch of 3 cultivars (SJ1, SJ2 and SJ3) was released in 1965 from selection of a segregating population introduced from abroad. Since there were a few local low-yielding varieties grown during that time, the new cultivars easily out yielded them. When Thailand produced surplus soybean during early 1970s, breeding objectives were set to produce the cultivars that met with international standard. The objectives included large seed (>14 g/100 seeds) and determinate growth habit with less photosensitivity (Na Lampang, 1977). Later, an outbreak of soybean rust prompted the breeders to set additional objectives to include resistance to major diseases, especially soybean rust, downy mildew, anthracnose, purple seed stain and bacterial pustule. In collaborative breeding effort with Japan International Cooperation Agency (JICA) during 1967-1976, two more cultivars (SJ4 and SJ5) were released to the farmers (JICA, 1977). They were very well accepted and dominated the planting areas for a full decade, until the cultivar "Chiang Mai 60" (CM60) was released in 1987. CM60 has been the most popular soybean cultivar during the past 2 decades, regardless about 10 more new cultivars were released by DOA, Khon Kaen University and Kasetsart University (KU) during the succeeding years. The main reason for the durable use of CM60 is because it is the most rust tolerant cultivar available in Thailand (Sopa *et al*., 2009).

The latest grain soybean cultivar released in Thailand is "Chiang Mai 5" (CM5) which is obtained from a mutated progeny of irradiated CM60. CM5 reacts as reddish brown type to soybean rust rather than as the tan type shown in CM60. It was officially released by CMFCRC in 2006 and quickly replacing CM60 in the rust infested areas. The resistant gene/QTL was mapped by KU around the SSR markers Sat472, Sat288 and Sat12 on linkage group G. In the future, this rust resistant gene will be deployed to other soybean cultivars through marker-assisted selection to assure that all novel soybean cultivars will possess soybean rust resistance. Selection can be done year-round regardless of the out break of the disease. In addition, KU is also mapping genes controlling fatty acid content in order to manipulate the level in soybean oil (unpublished data).

b. Breeding of vegetable soybean

There are 2 markets for vegetable soybean in Thailand, domestic and international. Mongkolsilp (2009) reviewed the status of vegetable soybean production in central Thailand which is the largest growing area for domestic markets. The cultivars used are mostly those of field soybean. However, there are some specific varieties chosen by the farmers themselves. These varieties were not officially released by the government but being kept by the farmers during collaborative field trials. The farmers saved the seeds for their own use based on the appearance of the plants, pods and seeds at the R6 to R7 stages when the soybeans are harvested for vegetable purposes. The most popular variety for domestic consumption is "Tharn Kasem" which has no known origin. The farmers and consumers prefer this variety owing to its intact pods (no splitting) after boiling, golden yellow looking pods and crunchy seeds. The other but less popular varieties are "Chiang Mai 1" bred by CMFCRC, and AGS292 introduced from AVRDC-The World Vegetable Center. Harvesting of vegetable soybean for domestic consumption is different from for exporting. The whole plants are cut, leaves and non-marketable pods are removed, leaving stem and branches with good pods on, ready for the markets where merchants buy it for boiling and distributing. Boiling for domestic consumption is considered "overcooking" by Japanese's Eda mame standard.

For export markets, the cultivars used are introduced from Japan. They are "Kaori", "Cha mame", No. 75, AGS292 and No. 2808. The first 2 cultivars are fragrant vegetable soybeans. The peculiar smell of special essential oil is produced by the soybean plants in the field as well as by the pods after boiling. The aroma comes mainly from the chemical 2-acetyl-1-pyrroline, the same chemical found in aromatic rice (Juwattanasomran *et al*., 2008). In 2009, Thailand is expecting to send over 20,000 t of boiled vegetable soybean pods to Japan. The pods that do not meet with the Japanese standard are consumed locally and command higher price as compared to vegetable soybean of the local varieties. Although the exported varieties yield over 6 t/ha of green pods, they require high inputs, especially fertilizers and high grade insecticides and fungicides. Thus CMFCRC and Mae Jo University (also in Chiang Mai province) have been breeding to improve vegetable soybean for domestic consumers (Sopa *et al*., 2009; Chotiyarnwong *et al*., 2009).

Production of *Vigna* in Thailand

Among the *Vigna* produced in Thailand, mungbean, blackgram and rice bean are the most economically important, occupying the annual planting area of 200,000, 100,000 and 20,000 ha, respectively (http://ssnet.doae.go.th, 2009). During 1960 to 1990, Thailand was the world's largest exporter of these 3 crops, but later lost its position to China, Myanmar and Vietnam (Srinives, 1996). These 3 legumes are produced mainly on the same area, i.e. the lower northern and the upper central parts of Thailand. Mungbean is cultivated in 2 major seasons, i.e. wet and dry. Wet season mungbean is produced from the corn-based cropping system. Mungbean seeds are broadcasted after corn harvesting (August to September), when the soil is still moist for germination and there are a few rains left to assure pod and seed development. Dry season mungbean is grown in the paddy field after rice harvesting when there is moisture left in the soil or when supplemented irrigation is available. When most pods are mature, the whole plants will be cut and threshed by machine. Seed yield of mungbean is usually low especially when there is no rain after flowering. The average yield in Thailand is about 800 kg/ha, although low compared to the other *Vigna*, considered high compared to the major growing countries like India or Pakistan. The yield in South Asian countries is lower due to the infestation of mungbean yellow mosaic virus (MYMV) disease prevailing in those areas. MYMV had been found in Thailand during early 1970s, threatening major mungbean areas in Thailand. The disease disappeared for about 30 years and was found again in 2007 in the area of over 2,000 ha in Sukhothai province. Staff from CNFCRC and KU are carefully monitoring the spread of the disease.

Production of black gram in Thailand is on the decline. During 1970s, Thailand used to grow the crop over an area of 100,000 ha. Black gram is sown after field crops (late rainy season-August to September) or rice paddy (dry season-December to January) as with mungbean. The plants are left in the field until most pods are mature, then the farmers roll the stems together with pods and let dry in the field for a few days before threshing by machine. Black gram yield in Thailand is higher than mungbean with the average of 1,000 kg/ha. Due to poor handling by some farmers during harvesting and threshing, some seed lots are contaminated with the fungus *Macrophomina phaseolina*. The infected seeds are moldy during sprouting and thus rejected by Japanese importer (Ngampongsai *et al*. 2004). The Japanese markets prefer clean and uniformly black seeds with 100 seed weight of over 5 g. The Indian markets have less strict quality requirements but give lower price.

Rice bean in Thailand is produced only in the early rainy season corn field. Rice bean seed is broadcasted a few weeks before corn harvesting (around September), utilizing the moisture in the soil or late rains for germination. After the corn ears are picked, the standing mature corn stalks serve as poles to support the viny growth of rice bean plants until reaching maturity. Since rice bean is a short-day plant, date of broadcasting is crucial for sufficient vegetative growth before flowering. The average yield of rice bean in Thailand is slightly higher than that of black gram, i.e. 1,100 kg/ha. The seed is mainly grown for export to Japan as a supplement to azuki bean in a variety of cake.

Breeding of *Vigna* in Thailand

Among the three major *Vigna*, only mungbean has a strong breeding program in Thailand. Two DOA experiment stations, i.e. CNFCRC and Phitsanulok Field Crops Experiment Station (PFCES) have mungbean as their mandate crop. AVRDC-The world Vegetable Center (AVRDC) had a long-term contract agreement with KU on mungbean breeding. Yet DOA and KU also have a strong relationship that facilitates collaborative mungbean research between CNFCRC and KU during the past 30 years.

There was a record of early indigenous mungbean varieties grown in Thailand dating back to 1937. Not until 20 years later (1957) that black gram was first mentioned as "Indian mungbean", which was probably introduced through Burma (Srinives and Rojanaridpichet, 1986). The first mungbean variety, "U-Thong 1" was officially released by DOA in 1976. It was an introduced accession (pedigree not known) from the Philippines and selected based on its high yield, large seed and more even maturity than the local varieties. The cultivar boosted mungbean growing area in the country to over 500,000 ha per annum during 1980s to 1990s. Later, KU released 2 cultivars "Kamphaeng Saen 1" (KPS1) and "Kamphaeng Saen 2" (KPS2) in 1986, specifically for dry and rainy season plantings, respectively. These 2 cultivars were mass-selected from breeding lines VC1973A and VC2778A originally selected by AVRDC in Taiwan. Both cultivars gave higher seed yield and yet earlier and more resistant to cercospora leaf spot and powdery mildew diseases than U-Thong 1 (Srinives, 1994). Both breeding lines were later released in over 10 other countries and are still directly grown or used in breeding programs nowadays.

Vigna spp. in the sub-genus *Ceratotropis* are abundant in Thailand and germplasm of these species have been collected, evaluated and documented (Srinives *et al*., 1996; Tomooka *et al*., 1997, 2000, 2003); Ngampongsai and Sinsawat Forrer, 2007). Wild forms of *V. exilis*, *V. grandiflora*, *V. hirtella*, *V. minima*, *V. mungo* var. *silvestris*, *V. reflexo- pilosa* var. *glaba*, *V. tenuicaulis*, *V. trinervia* var. *trinervia* and *V. umbellata* and weedy or escaped *V. radiata* were found in Thailand (Table 1). The collaboration with National Institute of Agrobiological Sciences (NIAS) in Tsukuba, Japan, allowed the breeding project of DOA and KU to have an access to their expert staff (Drs. D. Vaughan, N. Tomooka and A.

Kaga), as well as some germplasm available at NIAS genebank.

Presently, there are 4 popular mungbean cultivars recommended for the farmers in Thailand. They are KPS1, KPS2, "Chai Nat 36" and "Chai Nat 72". Mungbean breeders at CNFCRC are still breeding for powdery mildew resistance through either backcrossing to the resistant source (VC1163) or mutation breeding. There are 2 new breeding objectives, i.e. resistance to MYMV disease and high starch content for noodle industry (Masari *et al*., 2009). At KU, the prime breeding objectives are resistance to powdery mildew, Cercospora leaf spot, MYMV and bruchids. Intensive studies to map the gene(s) controlling these desirable traits are underway. Marker-assisted selection is necessary for these traits because powdery mildew is a dry season disease while Cercospora leaf spot is a wet season disease. MYMV is occasionally found in Thailand and has to be collaboratively phenotyped at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, Pakistan. While resistance to bruchid insects is difficult and costly, MAS will facilitate a year-round selection scheme. KU breeders are also exploring the possibility of producing hybrid mungbean (Sorajjapinun and Srinives, 2009).

Black gram improvement is solely conducted by DOA at CNFCRC and PFCES. The first black gram cultivar "U-Thong 2" -originally Accession No. 68/71- was released in 1978 and became the only recommended black gram for over a decade. The second cultivar, "Phitsanulok 2" (PSL2) was released from an Indian black gram line (PI 288603 or BC 48) in 1990. The objectives for black gram improvement are high yield, uniformly large seed (>5 g/100 seed) and high sprouting rate. The first black gram cultivar improved through hybridization and selection is "Chai Nat 80" (CN80). It was selected during 1989 to 2003 from the segregating progenies of the cross between the local variety "Prachin" and the introduced "NBG5". CN80 gave the average yield of over 1000 kg/ha with larger seed and higher sprouting rate (1:6 vs 1:5) than PSL2 (Masari *et al*., 2009). Since more sprouting factories are using black gram for making sprouts at the moment, there is a very small amount left for export.

There has been no rice bean breeding project in Thailand. The farmers save their own seeds for the next season but also made selection for large and uniformly red seed. Rice bean is more resistant to diseases than mungbean and back gram, thus the farmers require no specific resistant varieties.

Conclusions

1. Soybean is the only *Glycine* grown in Thailand while mungbean, black gram and rice bean are the major *Vigna*. Although the areas planted to these crops have reduced by almost 3 fold during the past 15-20 years, they are still economically and socially important.

2. Thai farmers produce both field and vegetable soybeans. Field soybean is produced for only 5% of the national demand, while vegetable soybean is produced either for domestic consumption or for export to Japan using specific cultivars for the purposes.

Table 1. Wild Asian *Vigna* (subgenus *Ceratotropis*) found in Thailand.[1]

Section	Species	Main distribution
Angulares	*V. exilis*	Thailand
	V. hirtella	North India, Southeast Asia
	V. minima	Southeast Asia, New Guinea
	V. reflexo-pilosa var. *reflexo-pilosa*	India, Mauritius, Philippines, Vietnam
	V. tenuicaulis	Thailand, Myanmar
	V. trinervia var. *trinervia*	South and Southeast Asia, Madagascar, New Guinea
	V. umbellata (wild)	Northeast India, main land Southeast Asia
Ceratotropis	*V. glandiflora*	Thailand, Cambodia
	V. mungo var. *silvestris*	India, Myanmar, Thailand
	V. radiata (weedy or escaped)	-
Aconitifoliae	-	South Asia

[1]From Tomooka *et al*. (2003)

3. Thai field soybean cultivars out yielded most local Myanmar cultivars and thus opened an opportunity to promote soybean production in Myanmar using Thai cultivars/breeding lines.

4. Soybean breeding in Thailand is based mainly on conventional methods. Recently, SSR markers linking to rust resistance were identified and are promising for use in marker-assisted selection. Markers linking to contents of some fatty acids and aroma are being located.

5. *Vigna* crops in Thailand are produced as a second crop in cropping systems, i.e. after rice or field crops, especially corn.

6. Breeding activities for *Vigna* during the past several years have been devoted to mungbean and black gram, but not for rice bean.

7. With aids from Japanese Government and FAO, CNFCRC and KU have collected, catalogued and maintained accessions of *Vigna* spp. *In situ* conservation and characterization were also performed.

8. KU is the leading institute in Thailand working on markers of economically important traits in *Glycine* and *Vigna*, aiming to use in MAS.

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