Chapter 5

General discussions

5.1 Condition for gall midge damage in farmer's rice field

This thesis confirmed previously reported studies (Hidaka *et al*., 1974; Tayathum *et al*., 1995) of the environmental condition of the rice field where the rice crop is infested and damaged by the gall midge. The survey found gall midge infestation of rice fields in the foothills, with a small area of rice surrounded by forested mountains dense with vegetation such as Mae Moot village. In this village, the climate conditions showed the rain fall more than 1000 mm and average mean temperature range in 25.5 – 27.7 ºC during monthly wet season. Previous studies suggested that the optimum of rice gall midge infestation was found at average temperature between 23.4°C and 26.9°C, with high relative humidity of 85% to 95%, cloudy day with about 4 sunshine hours and at more than 600 mm of rain during the growing season (Majumder *et al*., 2003). The climatic condition in wet season favored the survival rate of adult higher, number of eggs per female increased, egg hatching at high percentage and almost of hatched larvae entrance to growing points of rice plants (Hidaka *et al*., 1974). In addition, the high infestation by gall midge was associated with popular but susceptible rice varieties in paddy field such as KDML105, RD6, RD1 etc. In chapter 1, farmers cultivated RD6 (popular variety) and Nahng Gao (local Karen variety) which both varieties had high gall midge infestation and associated with high number of gall midge in rice field. The result showed the fluctuation of adult gall midge in 2 - 3 cycles during the tillering to heading stage as corresponding with Hidaka *et al.* (1974). After that the rice season, the rice gall midge migrated to alternative host plants during dry season for wait damage rice plant on next season. It has been previously reported that there are five host plants; *Leersia hexandra* Sw. (swampy rice grass), *Echinochoa colona* (L.) Link (jungle rice), *Paspalum scrobiculatum* Linn. (rice grass paspalum) , *Ischaemum rugosum* salisb. (wrinkle duck-beak) and *Oryza rufipogon* Griff. (common wild rice) which can be used as indicators of the prevalence of the gall midge and the potential damage to susceptible rice varieties (Hidaka *et al*., 1974). This study found 4 out of 5 of the alternative host plants in or near the rice field at Mae Moot village.

5.2 Responses to gall midge infestation in rice genotypic variation

The different responses to gall midge infestation have been demonstrated among the rice varieties. The percentage of gall midge infestation is a suitable indicator of genotypic variation to gall midge infestation for classification to gall midge resistance or susceptible varieties (Tayathum *et al*., 1995). The present study demonstrated that Muey Nawng and Phrae 1 were resistant to gall midge but Nahng Gao and RD6 were susceptible (Experiment 3.2.1). Therefore, the comparisons among the four rice varieties showed the differential responses to gall midge damage. The overall susceptible varieties infestation by gall midge was associated with the decreasing of grain yield (Hidaka *et al*., 1974). However, the present study has shown that infestation may or may not result in rice yield loss. The evidence that gall midge infestation can lead to yield loss was found in the susceptible varieties indicated by the highest percentage of gall midge infestation, unfilled grain and unproductive tillers in this study.

The reactions of resistant varieties were varied the responses to gall midge infestation (Sardesai *et al*., 2001). The no infestation by gall midge in resistance varieties was simple and easy to identify genotypic resistance gene. Likewise, the non-preference indicator of rice resistant varieties was no damage by insect which is defined as some unattractive characteristics for oviposition, feeding and shelter for the insect pest (Pathak and Saxena, 1976). This was confirmed the present study that the resistance varieties; MN1, MN6, MN20 and Muey Nawng 62 M was resistant to gall midge damage even in the highly gall midge attraction by lighting condition (Experiment 3.2.3). In contrast, the high gall midge infestation by accentuated with lighting in MN8, MN9, KDML105 and RD6 (susceptible varieties) were associated with the lowest grain yield, the highest unfilled grain and unproductive tillers. Harris *et al*. (2003) showed that the sensitive rice varieties can produce the highly soluble amino acids and sugars in nutritive tissue for growth stages of gall midge. In addition, the feeding and salivary secretion by the larvae of gall midge turn the growing point of rice plant into a gall and exhibit the external symptom known as silver shoot (Chiu, 1980 cite by Sardesai *et al*., 2001). The gall midge infestation results in profuse tillers and stunting of rice plant, but few of the tillers bear panicles (Tayathum *et al*., 1995). However, the susceptible varieties KDML105, RD6, MN8 and MN9 can produce similar number of normal tillers at vegetative stage and the number of normal tillers and panicles at maturity as resistant varieties at highly gall midge infestation (Experiment 3.2.3). Similar result was found in the absence of gall midge condition, the susceptible varieties KDML105, RD6, MN9 and MN8 had more or the same productive tillers, normal tillers, panicles and grain yield with resistant varieties. These results can be explained by the study of Inthavong (1999) suggested that the infestation by rice gall midge in susceptible varieties showed the production of more new tillers to replace the tillers that were damaged and become silver shoots in the vegetative stage. However, the infestation by rice gall midge on rice plant resulted in the compensatory production of new tillers which developed in response to gall midge infestation but the compensation was not sufficient to make up for the loss of yield due to the damage tillers (Nacro *et al*., 1996). Moreover, other studies reported about the antibiosis (Omoloye and Vidal, 2007) and tolerance indicator (Omoloye *et al*., 2002) of resistance varieties to gall midge but not the case for this study.

5.3 Variation of local Muey Nawng rice varieties

The local rice varieties maintained by traditional farmers are highly variable within and among accessions (Chang, 1976). In addition, different local rice varieties may be given similar names and different names could be applied to the same varieties name in different locations (Harlan, 1992). Similarly, the pervious study by Supamongkol (2006) found that seven accessions of local Muey Nawng were resistant to gall midge damage but varies in the grain yield when compared in three locations in Chiang Mai province. However, in the present study I compared 20 local Muey Nawng accessions collected from different farmers. The results showed variation in gall midge damage from no infestation to high percentage of gall midge infestation with the same percentage of susceptible check San-pah-tawng1 (Experiment 3.2.2). Interestingly, different gall midge populations from different provinces had different effects on the different Muey Nawng accessions. The results of experiment 4.2.1 illustrated different degree of the interaction between the 20 local Muey Nawng accessions and the six populations of gall midge. These variations of gall midge infestation in 20 local Muey Nawng accessions were varied from no infestation to high percentage of gall midge infestation or highly resistant to highly susceptible reactions. This study confirmed that different rice varieties vary in the degree of the resistant to different biotypes of gall midge infestation (Kaload and Bentur, 1989; Tayathum *et al*., 1995; Nwilene *et al*., 2002).

In addition, genetic variation of 20 local Muey Nawng accessions was also determined for morphological characters and molecular markers. The results illustrated that genetic variation was found among and within accessions of local Muey Nawng. However, morphological variation was difficultly to classify between accessions of local Muey Nawng. The morphological variation within accessions of local Muey Nawng were found in seed length, width and thickness, color of leaf sheath, leaf blade, ligule, apiculus, stigma, husk and days of heading. Moreover, this study presented the variation of seed quality which was percentage of glutinous or non-glutinous types and alkaline spreading value. The results also corresponds with other studies that the variation within and among accessions of local rice varieties exhibited variation in morphological characters and seed quality (Meesin, 2003; Supamongkol, 2006; Pintasen *et al*., 2007; Phattarakul, 2008). In addition, common phenotypes generally found in all 20 local Muey Nawng accessions were colorless auricle, 2-cleft ligule shape, erect plant type, green node and green internode.

The genetic diversity analysis using 4 microsatellite markers was found within and among 20 local Muey Nawng accessions. Indeed, average gene diversity within accession (*Hs*) was 0.17 and polymorphic alleles were 15 alleles. However, genetic diversity index (*He*) within accession was found in 13 accessions while no variation was found in seven accessions in four SSR loci. Genetic differentiation among 20 local Muey Nawng accessions (F_{ST}) was 0.40. This implied that 40% of total genetic variation was the differentiation among 20 local Muey Nawng accessions and 60% was the differentiation within accessions. Supamongkol (2006) found that genetic variation within a different set of 18 local Muey Nawng accessions analysis show average gene diversity in 0.112 (H_s) and polymorphic alleles in 26 alleles. Among 18 accession 22.7% of total variation was the differentiation among 18 accessions and 77.3% was the differentiation within accessions. Although the numbers are different, the same conclusions can be made from Supamongkol (2006) and the present study that the majority of genetic variation is found within accessions of the local rice variety Muey Nawng, with genetic differentiation among the accessions accounting for the smaller proportion of the genetic variation.

5.4 General conclusion

This study concluded that the numbers of gall midge infestation varied with rice varieties and time during the rice growing season. The rice varieties differ markedly in resistant to gall midge infestation. Susceptibility to gall midge in rice varieties is indicated by high number of silver shoots, unproductive tillers, unfilled grain and the loss in grain yield. Resistance to gall midge in local rice variety Muey Nawng is indicated by absence or very few silver shoot and lack of impact on components of grain yield such as number of unproductive tillers and unfilled grain. However, genetic variation in resistance to gall midge infestation was found to vary among the 20 Muey Nawng accessions. Some accession of Muey Nawng actually responded to gall midge in the same ways as susceptible checks. In addition, there is the factor of different gall midge populations from different location in Thailand, that affected different accessions of Muey Nawng differently. One of these, MN6 was resistant to all six gall midge populations. In addition, local Muey Nawng accessions show a great amount of genetic diversity within and among accessions. The local Muey Nawng germplasm is a valuable source for gall midge resistance or use as a donor of the gall midge resistance trait in rice breeding program. It is, however, important to recognize that not all accessions of Muey Nawng are equally resistant to all gall midge populations. This study has also illustrated the range of functional diversity, in resistance to an insect pest, which can be found in a local rice variety that outwardly appears similar and go under the one name, Muey Nawng.

5.5 Further research

To make better use of resistance present in the local Muey Nawng germplasm, it should be necessary to understand the mechanism behind the resistance in Muey Nawng as well as the governing genetics. As the gall midge populations are also different in their virulence against the different genotype of Muey Nawng, the mechanism behind this interaction also needs to be better understood.