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Evaluation of Yield and Resistance to Powdery Mildew, *Cercospora* Leaf Spot and Cowpea Weevil in Mungbean Mutant Lines

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ABSTRACT

Ten mungbean mutant lines obtained from irradiation and chemical substances were tested against the 2 recommended varieties on resistance to the diseases and insect namely powdery mildew, *Cercospora* leaf spot and cowpea weevil. The 2 diseases using artificial inoculation were investigated in the greenhouse while cowpea weevil was studied under laboratory conditions. Apart from these, regional yield trial were also conducted at 7 experimental stations during the dry and rainy seasons of 1998. The investigation revealed the tested mutant lines to have potential development into new varieties. They were, M5-10 and M5-25 resistant to powdery mildew, M5-22 and M5-25 resistant to *Cercospora* leaf spot, M5-16 and M5-29 resistant to cowpea weevil and the other 5 lines of M4-2, M5-1, M5-5, M5-15 and M5-28 with trend of producing good yields.

Key words : mungbean mutant lines, *Cercospora* leaf spot, powdery mildew, cowpea weevil, yield

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) has been grown in Thailand for a long period of time but the yield is still low due to several problems including disease and insect infestation. The major diseases are *Cercospora* leaf spot (CLS) and powdery mildew (PM) while bruchids, bean flies and pod borers are found to be major insect pests (Srinives, 1996). Disease and pest controls by chemicals can somehow reduce plant damage, yet they are not practical for the conditions in Thailand. Chemical use not only increases cost of production but also is hazardous to man, domestic animals and natural enemies of pests.

Breeding of mungbean varieties for diseases and insect pests is probably the suitable method to problem-solving in the long run. The use of radiation and chemicals to induce mutation is one method employed in several plants including mungbean. Powdery mildew of mungbean is caused by *Erysiphae polygoni* DC. forming white hyphae, the type which looked very much like flour powder sprinkling on the plant. The disease starts on the lower leaves and spreads up to the upper ones under favorable conditions as dry season of cool weather.

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In such condition, the fungi would grow rapidly covering the whole leaf area. PM was found to reduce yield 40% (AVRDC, 1984) and the resistance to the disease was reported to be quantitative character controlled by polygenes rather than dominant gene.

Leaf spot of mungbean caused by *Cercospora canescens* is distributed by spores of infected leaves. The fungi forms brown spot with white or gray center surrounded by reddish brown margins. The disease is encountered during the rainy season of relatively hot and high humid conditions (Poehlman, 1991). The damages reduce mungbean yield by 47% (AVRDC, 1984). Chinsawangwattanakul *et al* (1981) also reported that under favorable conditions coupling with sufficient amount of fungal spores, mungbean was severely and rapidly infected resulting in yield reduction as occuring in the susceptible Uthong 1 and resistant Pagasu varieties to 68 and 35% respectively. Genetical studies revealed 1 pair of genes controlling leaf spot resistance with resistance dominant over susceptibility (Thakur *et al*, 1980; Laosuwan, 1988). However, the report of Leabwon and Oupadissakoon (1984) stated the leaf spot resistance to be controlled by additive gene with capacity to transmit 99 and 75% of broad and narrow senses respectively.

Tomooka *et al* (1981) reported that two species of weevils, *Callosobruchus maculatus* and *C. chinensis*, were the major insect pests of mungbean seed in Thailand causing low yield and decreased seed quality. They occur all year round. Field damage to pods and grain by *Callosobruchus* spp. were reported by Raina (1971) and by Gujar and Yadav (1978). However, the field damage to pods and grain by these bruchids is only a minor problem, when the major destruction to grain occurs during storage. At present, all recommended varieties of mungbean in Thailand are known to be susceptible to these insects.

The objective of the study was to evaluate 27 mutant lines of mungbean obtained from 500 gray of gamma irradiation and 1% ethylmethane sulphonate (EMS) treatment in comparison with 3 check varieties, KPS1, CN36 and Uthong 1, on disease resistance to PM and CLS by artificial inoculation at greenhouse conditions and insect resistance to cowpea weevil in the laboratory. Aside from evaluation for disease and insect resistances, regional yield trial of 12 mungbean mutant lines were employed in comparison with 2 check varieties, KPS1 and CN36.

MATERIALS AND METHODS

1. Evaluation for powdery mildew (*Erysiphae polygoni* DC.) resistance

1.1 Cultivation

Twenty seven mungbean mutant lines seeds obtained from gamma rays and ethylmethane sulphonate treatments (Wongpiyasatid *et al*, 1998) were grown in clay pots of 12 inches in diameter, 10 plants/line/pot comparing with the controls, KPS1, CN36 and Uthong 1. Randomized complete block design (RCB) was employed with 2 replicates.

1.2 Inoculum preparation and Inoculation

Leaves infected with PM were collected from the tested plot. Conidia of fungi collected using the camel brush were put into pasteurized distilled water in the beaker. The procedure was repeated several times until the 6×10^4 and 3.6×10^3 conidia/ml were reached in rep 1 and 2 respectively. Tween 20 was added to the inoculum at the rate of 0.1 ml per 100 ml solution in order to increase its sticker property.

The inoculation was undertaken in the greenhouse when mungbean was 25 days old after emergence. The preparation of plants before inoculation was made by ridding the old lower leaves while the second and third compound leaves were selected for inoculation. By pipetting, 0.02-0.2 and 0.2-0.5 ml/leaf inoculum for rep 1 and rep 2 respectively were dropped on each leaf blade. The loop was used to lightly smear inoculum all over the leaf, after which three wood sticks for holding plastic bag were placed in the pots. Big plastic bags were placed to cover the whole plants in each pot in order to keep the wind from blowing the fungal conidia away. Small holes in the bag bottom were made for ventilation as well as preventing heat-accumulation. The greenhouse floor was constantly soaked with water to decrease temperature and at the same time increased humidity to acquire better germination of conidia. After 5 days of covering, the pots were brought outside the greenhouse to obtain moisture from dew for good infection.

1.3 Disease assessment

Disease assessment of PM was made two weeks after inoculation using rating scale of 0-4. They were, 0 = clean leaves with no infection; 1 = 1-25% infection; 2 = 26-50% infection; 3 = 51-75% infection; 4 = 76-100% infection. Acquired infection scores were then used in calculation of Disease Index (DI) following Parry's adapted formula (Parry, 1990).

Disease index

$$= [(0 \times a) + (1 \times b) + (2 \times c) + (3 \times d) + (4 \times e)]/(a + b + c + d + e) \times 100/4$$

a, b, c, d and e are the amount of mungbean plants with levels of infection equal 0, 1, 2, 3 and 4 respectively.

1.4. Statistical analysis

Calculated DI was then statistically analyzed by adapting data into arcsine, analysis of variance and testing difference of averaged DI of each mungbean line using IRRI STAT Version 93/3.

2. Evaluation for *Cercospora* leaf spot (*Cercospora canescens*) resistance

2.1 Cultivation

Twenty seven mungbean mutant lines and the controls, KPS1, CN36 and Uthong 1, were grown in clay pots, 10 plants/line/pot. RCB was employed with 3 replicates.

2.2 Inoculum preparation and Inoculation

Chiangmai isolate of *C. canescens*, the one capable of causing severe leaf spot to mungbean varieties, was cultured on potato carrot agar under conditions of 24-25^{o}C and 12 hours of black and fluorescent lights period for 3 weeks. Water was then added to the medium on which the pathogen grew. The spores were swept off with needle and filtered once through fine-meshed cloth. Concentration of spores was later adjusted to 100 spores per ml. 0.1 Tween 20/100 ml inoculum was added for better infection.

The inoculation was conducted in the greenhouse when mungbean was 22 days old. 0.2 ml inoculum was dropped on the second, third and fourth compound leaves of mungbean, and was gently smeared all over the leaves. Big plastic bag was used to cover the pot with rope tightly tied around the bag-opening. Untieing the bag for ventilation and humidity control by mist-spraying for better infection were executed 3 times a day for 7 days. After that, the bag was left open and more ventilation was stimulated 3 times every day for the whole 14 days.

2.3 Disease assessment and statistical analysis

The same procedure of evaluation to PM resistance was employed.

3. Evaluation for cowpea weevil resistance

3.1 Preliminary test

Twenty seven mutant lines were

preliminarily evaluated for the weevil resistance against two recommended varieties, KPS1 and CN36. Mungbean seeds were kept at refrigerated condition for one week in order to disinfest the insects accidentally attached to the seeds. One hundred forty grams seeds of each variety/line was put into each plastic square box with mesh-screen on the lid for ventilation. In each box, 7 pairs of male and female of 1-3 days old cowpea weevil were placed and were left to mate and reproduce in the seeds. The number of first generation adults were recorded after one month.

3.2 The second test

The test following the pretest was conducted by screening the lines with low amount of the weevils from the pretest for confirmatory study. Six mutant lines were selected comparing with the recommended varieties, KPS1 and CN36. RCB with 4 replications was employed. Thirty gram seeds of each variety/line was put in the small plastic cup, 4 cups/variety or line; 1 cup represented 1 treatment. Two pairs of 1-3 days old *C. maculatus* were placed in each cup covered with small-holed lid for ventilation. The cups were kept under room temperature for one month, then the first generation of the weevil in each cup were counted. The damaged seeds were taken out and weighed. Percent damage of each variety/line was calculated. Data were statistically analyzed.

4. Regional yield trial

Twelve lines having high yield from preliminary yield trial were selected and tested in regional yield trial against the control varieties, KPS1 and CN36. RCB was administered with 4 replicates. Each one had row of 5 meter long, 4 rows per variety/line. Weed control, watering and insect pest spraying were given as required. Disease control was not applied since the kind and severity of any disease of each locality was to be checked. The experiment was undertaken in dry and rainy seasons of 1998 at 7 experimental stations namely, Chai Nat Field Crops Research Center (Chai Nat FCRC), Phitsanulok Field Crops Experiment Station (Phitsanulok FCES), Sri Samrong Field Crops Experiment Station (Sri Samrong FCES), Ban Mai Samrong Field Crops Experiment Station (Ban Mai Samrong FCES), Phetchabun Field Crops Experiment Station (Phetchabun FCES), Suranaree University of Technology and Ayutthaya Rajmongkol Institute of Technology.

RESULTS AND DISCUSSION

1. Evaluation for powdery mildew resistance

Inoculation of PM at greenhouse condition found mungbean to show quite distinct disease symptom even though degree of virulence was not so great owing to quite high temperature of 20-30^{o}C during 6:00-16:30 hrs. throughout the experimental period.

Analysis of variance revealed the level of infection among varieties/lines not to be statistically significant with DI ranging from 25.62 to 53.12. Still, it was found that lines M5-10 and M5-25 with DI = 25.6 and 30.0 respectively expressed better resistance to the disease than CN36 and KPS1, the standard varieties, and Uthong 1, the susceptible check, which had DI of 33.75, 48.12 and 37.50 respectively (Table 1).

The results indicated that the selected mutant lines were resistant to PM more or less the same level as the recommended varieties. The evaluation of resistance in the greenhouse also yielded similar results to the screening under natural conditions (Wongpiyasatid *et al*, 1998). However, it was noticable that the efficiency of powdery mildew inoculation highly depended upon weather temperature. The resistance is therefore, recommended to be evaluated under favorable conditions or controlled temperature and humidity. PM resistance evaluated at Asian Vegetable

Table 1 Disease index (DI) for powdery mildew of mungbean mutant lines and check varieties.

Variety/line	Ranks	DI [1]
M4-1	15	38.75 abc
M5-1	20	35.62 abc
M5-2	12	41.88 abc
M5-3	5	47.64 ab
M5-4	21	34.38 abc
M5-5	11	42.50 abc
M5-6	2	52.50 a
M5-7	1	53.12 a
M5-8	9	44.38 abc
M5-10	26	25.62 c
M5-11	24	32.50 abc
M5-13	10	43.26 abc
M4-2	17	38.12 abc
M5-15	13	40.62 abc
M5-16	22	33.96 abc
M5-17	8	45.62 abc
M5-18	2	52.50 a
M5-19	19	36.88 abc
M5-20	15	38.75 abc
M5-21	14	39.38 abc
M5-22	6	46.88 ab
M5-23	7	46.25 abc
M5-24	15	38.75 abc
M5-25	25	30.00 bc
M5-26	16	38.28 abc
M5-28	3	50.62 ab
M5-29	13	40.62 abc
CN 36 (check)	23	33.75 abc
KPS 1 (check)	4	48.12 ab
UT-1 (check)	18	37.50 abc
F-test		1.27 ns
C.V. (%)		21.1

ns =no significant

1 Data within columns, means followed by a common letter are not significantly different at the 5% level by DMRT.

Research and Development Center was generally field test during period of cool-dry weather. The greenhouse assessment by knocking spores from infected mungbean leaves onto mungbean seedlings also revealed the level of infection to be similar to that under natural conditions (AVRDC, 1981).

2. Evaluation for *Cercospora* leaf spot resistance

By ANOVA, mungbean was found to show distinct symptom of leaf spot with statistical difference among varieties/line (F-Test = 2.70 **; CV = 11.9%). M5-22 and M5-25 gave good resistance to the disease and were noticed to be significantly different with DI = 51.41 and 51.45% compared to 74.95 and 74.96% of CN36 and KPS1 respectively (Table 2).

The leaf spot severity caused by *C. canescens* depends on 2 major factors: first, infectivity of the pathogen to mungbean leaves; second, toxic cercosporin produced by the pathogen. Great infectivity will bear several wounds while lightly toxic cercosporin causes desiccated tissue and rapidly expands the wounds. Since the two factors directly influence disease severity, the variety should be screened to possess gene resistant to infectivity as well as to toxic cercosporin (Srihattagum *et al*., 1998).

Owing to high infectivity to leaves, large amount of spots were produced in every variety/line causing various degrees of severity with DI quite high. Comparison of infected leaf areas revealed fast expansion of lesions in Uthong 1. Green tissue surrounded wound rapidly turned to yellow and brown resulting in desiccated leaves and final death. This showed high susceptibility of Uthong 1 to toxic cercosporin. As for CN36 and KPS1, slow expansion of wound took place with tissue around wound turning from green to reddish purple then brown causing dried leave towards slow death. The character expressed moderate

Table 2 Disease index (DI) for *Cercospora* leaf spot of mungbean mutant lines and check varieties.

Variety/line	Ranks	DI [1]
M4-1	26	52.46 ef
M5-1	22	61.53 c-f
M5-3	23	57.11 c-f
M5-4	10	70.25 b-f
M5-5	13	68.41 b-f
M5-7	25	53.89 def
M5-8	14	67.89 b-f
M5-10	6	74.75 bcd
M5-11	19	62.75 c-f
M5-13	20	62.75 c-f
M4-2	24	54.36 def
M5-15	17	64.92 c-f
M5-16	7	74.02 b-e
M5-17	9	71.46 b-f
M5-18	12	68.70 b-f
M5-19	3	77.49 abc
M5-20	18	64.16 c-f
M5-21	16	65.98 c-f
M5-22	28	51.41 f
M5-23	21	62.46 c-f
M5-24	2	85.96 ab
M5-25	27	51.45 f
M5-26	8	72.87 b-f
M5-28	11	69.20 b-f
M5-29	15	67.60 b-f
CN 36 (check)	5	74.95 bcd
KPS 1 (check)	4	74.96 bcd
UT-1 (check)	1	90.50 a
F-test		2.70**
C.V. (%)		11.9

**= significant at 1% level

1 Data within columns, means followed by a common letter are not significantly different at the 5% level by DMRT.

resistance to cercosporin while lines M5-22 and M5-25 appeared to be more highly resistance to cercosporin than the controls, with the amount and expansion of wound less than those found in the controls.

3. Evaluation for cowpea weevil (*Callosob-ruchus maculatus*) resistance

1. Preliminary test

Table 3 shows the wide range of number of dead weevils from 22 in M5-16 to 161 in M4-2. Comparing with the controls, 18 lines were found to have less insects. The difference of reproduction might depend on different quality of nutrient in each line or toxicity of some chemical compounds to the development of insects. However, only six mutant lines were selected for further experiment to confirm their potential resistance to *C. maculalus*.

2. The second test

The test followed the above pretest revealed M5-29 to be the least in terms of number of emerging adult weevils, weight and percent of damaged seeds with M5-16 the next least in line (Table 4). Compared to the controls, KPS1 and CN36, M5-29 was significantly less in the mentioned characters, while M5-16 was more or less similar to both checks. It was also noticed that both dead and alive weevils were encountered in all varieties/lines while in M5-29 and M5-16 only dead weevils were found. The mortality might be contributed to some toxic chemicals in the seeds. Kitamura *et al* (1990) reported that the substance in TC 1966, a strain of wild mungbean, exhibited a complete resistance against *C. chinensis*. The substance which strongly inhibited the larval growth of weevils was a polysaccharide. They also suggested that the substance was water soluble with a high molecular weight and exhibited heat and protease-stable characteristics. Trypsin inhibitor, an anti-nutritional component found in the seed, was also revealed to be partially associated with bruchid resistance in

Table 3 The amount of cowpea weevil, *C. maculatus*, in each treatment (27 mutant lines against 2 check varieties) in the preliminary test.

Variety/line	No. of insect	Variety/line	No. of insect
M4-1	25	M5-17	99
M4-2	161	M5-18	120
M5-1	29	M5-19	92
M5-2	143	M5-20	95
M5-3	100	M5-21	153
M5-4	170	M5-22	100
M5-5	122	M5-23	51
M5-6	102	M5-24	88
M5-7	111	M5-25	68
M5-8	23	M5-26	116
M5-10	65	M5-28	49
M5-11	130	M5-29[1]	26
M5-13	31	CN 36 (check)	113
M5-15	120	KPS 1 (check)	111
M5-16[1]	22		

1 all weevils found dead

Table 4 The amount of weevil, *C. maculata*, weight of damaged seed (g) and % damaged seed of (6 selected mutant lines against 2 check varieties) in the second test.

Variety/line	No. of insects[1/]	Damaged seed (g)	(%)
M4-1	60 b	8.23	27.44
M5-1	83 b	9.82	32.73
M5-8	80 b	10.04	33.45
M5-13	77 b	9.33	31.09
M5-16	56 ab	7.01	23.36
M5-29	26 a	5.45	18.15
KPS1 (check)	63 b	8.56	28.53
CN 36 (check)	65 b	9.28	30.92
F-test	2.64*	2.07 ns	2.07 ns
C.V. (%)	34.8	25.6	25.6

* = significant at 5% level,
ns = no significant
1/ Data within columns, means followed by a common letter are not significantly different at the 5% level by DMRT

many legume species. Although isolated trypsin inhibitor from cowpea was found to be toxic to *C. maculatus* when incorporated in the artificial diet, their contribution to resistance in the intact seeds requires further investigation (Birch *et al*, 1985). The results along with the report of Kitamura *et al* (1990) and Brich *et al* (1985) confirmed the pretest's results suggesting different quality of nutrient and/ or toxic substances that caused different development of the weevil or mortality. However, further chemical screening of mungbean seeds for the cause of resistance against *C. maculatus* along with study on combined effects of several components must be pursued.

4. Regional yield trial

Table 5 shows mungbean yields obtained from 7 locations during the dry and rainy seasons of 1998. Yields of tested lines were found to vary among locations but not to be statistically different among themselves at each place except for the experiment in the late rainy season at Sri Samrong FCES and Phitsanulok FCES. Lines M5-1 and M5-15 planted at Sri Samrong FCES were revealed to give highest yields of 266.67 and 260.27 kg/rai compared to 219.84 and 222.88 kg/rai of the controls KPS1 and CN36, respectively. As for yield trial at Phitsanulok FCES, mutant of line M5-11 yielded the product of 228.96 kg/rai while those of the controls, CN36 and KPS1, equaled 238.87 and 194.31 kg/rai respectively.

Averaging of yields from every location found line M5-5 and M5-1 to produce highest yields of 243.83 and 235.49 kg/rai respectively while those of CN36 and KPS1 were 228.16 and 213.15 kg/rai respectively.

Table 6 presents damaging levels of both PM and CLS by visual rating. However, each disease occurrence at each location was not that severe since the infection could occur only after podding started. The severity will increase with increasing full development of seeds, hence not much direct effect to yield observed. Comparison of natural to artificial infection of each line revealed not to be quite agreeable with each other which were probably caused by non-severity of both natural and artificial infection and the inoculate resulting in nearly similar levels of damaging of both. According to the report of AVRDC (1981), the degree of virulence highly depended on weather conditions especially temperature and humidity. Artificial inoculation in the greenhouse will give good results provided that favorable temperature and humidity being monitored. Yet, the inoculation in this experiment was undertaken under natural condition not in the controlled temperature and humidity chamber.

Although most mutant lines tested did not differ from the checks in terms of yield and severity of the 2 diseases, some lines expressed satisfactory characters of yields, such as, seed size, number of pods per plant. M5-5 and M5-1 lines with highest averaged yields obtained from all locations were considered to have potential development into new varieties. Another interesting line was M5-8 grown at Suranaree University of Technology which was found to have high yield of 399.30 kg/rai and number of pods equalling 45 compared to 27 and 32 pods of KPS1 and CN36 respectively.

CONCLUSION

All ten good lines namely M5-10, M5-25, M5-22, M5-29, M5-16, M4-2, M5-1, M5-5, M5-15 and M5-28 with resistance to diseases and insects and trend of good yield obtained from the experiments will be furtherly screened to acquire the best agronomic property, should the program be continued for confirmation. These lines will be tested against the 2 controls, KPS1 and CN36. In addition, seeds of M5-16 and M5-29 which were found to be resistant to cowpea weevils in either

Table 5 Yield (kg/rai) of mungbean obtained from regional yield trial at different locations in dry season and rainy seasons, 1998.

	Dry season		Early rainy season	Late rainy season							
Variety /line	Chai Nat FCRC[1]	Phitsanulok FCES[2]	Chai Nat FCRC	Chai Nat FCRC	Sri Samrong FCES[3]	Phitsanulok Samrong FCES	Ban Mai FCES[4]	Phetchabun FCES[5]	Suranaree U. of Tech.[6]	Ayutthaya Rajmongkol Inst. of Tech.[7]	Ave,
M 4-2	219.47	140.80	240.83	228.42	247.89 ab	164.53 c	217.00	213.77	348.50	273.32	229.45
M 5-1	210.12	170.18	218.85	257.18	266.67 a	134.89 cd	235.50	228.40	350.00	283 .12	235.49
M 5-4	248.08	123.20	256.17	224.68	220.69 bc	192.73 abc	219.00	215.87	323.30	222.08	224.58
M 5-5	229.26	149.68	225.79	219.34	260.27 a	-	228.42	228.97	382.50	270.20	243.83
M 5-7	219.60	167.79	194.68	183.73	221.44 bc	178.97 abc	215.50	221.13	367.50	220.88	219.12
M 5-8	203.20	133.33	195.47	210.12	209.12 c	176.31 abc	221.50	212.62	399.30	272.60	223.36
M 5-11	219.05	143.87	238.40	219.47	220.85 bc	228.96 ab	217.50	219.02	326.80	221.88	225.58
M 5-15	189.60	147.39	182.84	238.21	239.36 abc	175.33 bc	209.00	210.16	365.30	262.68	221.99
M 5-16	187.68	176.29	244.56	245.45	211.34 c	190.12 abc	223.00	207.10	327.00	170.88	218.34
M 5-22	248.30	129.93	214.07	183.91	247.34 ab	144.00 c	231.50	191.80	317.30	237.32	214.55
M 5-28	207.12	141.20	199.00	185.68	232.96 abc	82.22 d	228.00	194.71	336.00	224.00	203.09
M 5-29	205.04	135.60	162.69	244.32	226.03 bc	181.27 abc	222.00	205.21	352.80	236.60	217.16
KPS 1 (check)	211.24	141.79	173.31	192.53	219.84 bc	194.31 abc	223.08	204.08	329.50	241.80	213.15
CN 36 (check)	237.65	139.86	215.77	228.73	222.88 bc	238.87 a	219.50	210.35	344.30	223.68	228.16
F-test	ns	ns	ns	ns	**	*	<1	<1	<1	ns	
C.V. (%)	15.4	18.9	16.6	16.0	8.7	18.4	9.2	15.2	15.8	18.2	

1 Chai Nat FCRC = Chai Nat Field Crops Research Center
2 Phitsanulok FCES = Phitsanulok Field Crops Experiment Station
3 Sri Samrong FCES = Sri Samrong Field Crops Experiment Station
4 Ban Mai Samrong = Ban Mai Samrong Field Crops Experiment Station
5 Phetchabun FCES = Phetchabun Field Crops Experiment Station
6 Suranaree U. of Tech. = Suranaree University of Technology
7 Ayutthaya Rajmongkol Inst. of Tech. = Ayutthaya Rajmongkol Institute of Technology

Data within columns, means followed by a common letter are not significantly different at the 5% level by DMRT

Table 6 Visual rating and disease index (DI) of powdery mildew and *Cercospora* leaf spot in mungbean lines/vairties planted under field and greenhouse conditions in 1998.

Variety/line	Powdery Mildew						*Cercospora* Leaf Spot				
	L_1	L_2	L_3	L_4	Ave.	DI	L_5	L_6	L_7	Ave.	DI
M 4-2	3	3	3.25	2.13	2.85	38.12	2	3.25	3	2.75	54.36
M 5-1	3	3.75	3.5	2	3.06	35.62	2.25	3	2.25	2.50	61.53
M 5-4	3	3.25	3	1.88	2.78	34.38	2	3.25	2.88	2.71	70.25
M 5-5	2.5	3	2.5	2	2.50	42.50	2.5	3.25	2.75	2.83	68.41
M 5-7	3	3	2.75	1.75	2.63	53.10	2	3.25	3	2.75	53.89
M 5-8	3	2.75	3.25	2.25	2.81	44.38	1.75	3.25	4.12	3.04	67.89
M 5-11	2.5	3.25	3	2.38	2.78	32.50	1.75	3	2.75	2.50	62.75
M 5-15	3	3	3.75	1.88	2.91	40.62	2	3	2.75	2.58	64.92
M 5-16	2.5	3.25	3	1.63	2.60	33.96	2.75	4.25	2	3.00	74.02
M 5-22	3	3	3	1.88	2.72	46.88	2	3.5	3.12	2.91	51.41
M 5-28	2.5	3.5	2.75	2.13	2.72	50.62	2	3	2.88	2.63	69.20
M 5-29	3	3.5	3.25	2.13	2.97	40.62	2	3	2.25	2.42	67.60
KPS 1 (check)	3	2.75	2.75	2	2.63	48.12	2	3.25	3.5	2.92	74.96
CN 36 (check)	3	3.25	3.25	2	2.88	33.75	2	3	2.62	2.54	74.95

L_1 = Chai Nat Field Crops Research Center, dry season
L_2, L_6 = Chai Nat Field Crops Research Center, late rainy season
L_3 = Ban Mai Samrong Field Crops Experiment Station, late rainy season
L_4, L_7 = Suranaree University of Technology, late rainy season
L_5 = Chai Nat Field Crops Research Center, early rainy season
DI = disease index under greenhouse condition
Rating Score: 1 = no infection 5 = severe infection

preference or antibiosis mechanism under storage conditions would be investigated employing chemical screening for predictive result. Hence, proper procedure will then be chosen for advancing the resistance study to the stored insect in the future.

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