CHAPTER 4

RESULTS

4.1 Morphological characteristics, yield evaluation and seed multiplication

The study on plant growth characteristics and yields of 7 pea lines/cultivar which grown in the greenhouse were conducted at Pang Da Royal Agricultural Station from November 2006 to March 2007. The objectives of this study were to observe growth and yields of those pea lines/cultivar and, moreover, increase number of seeds for further trials.

4.1.1 Flowering

4.1.1.1 Days to first flowering and blooming

Generally, flower initiation time defined as the total number of days from sowing until first flowering occurred on axillary bud of the shoot meristem (Muehlbauer, 1997). However, in this study, number of days of first flowering and blooming was counted from transplanting. The average number of days to first flowering of 7 pea lines/cultivar was between 27.93-41.60 days (Table 4.1). It was found that the average number of days to first flowering of line No.5 was earlier than other lines/cultivar with an average 27.93 days followed by lines No.4, P117, cultivar Fang No.7, lines No.3 and P185 with an average 33.93, 34.73, 36.07, 38.80 and 39.40 days, respectively, while the average number of days to first flowering of line P309 was the latest at 41.6 days. Flowering time, which is defined as the total numbers of days from transplanting to opening of the first fully developed flower (corolla color visible). In this study, the results showed that the first blooming of line No.5 was the

earliest one among other lines/cultivar within 30.6 days. The duration from the flower bud to flower open was 2.67 days, while the latest first blooming found in line P309 within 45.80 days and their duration from flower bud to flower open was 4.20 days. The shortest duration from flower bud to flower open was cultivar Fang No.7, within 2 days (Table 4.1).

Table 4.1 Morphological characteristics, number of days on first flowering, blooming, pod setting and first flowering node of 7 pea lines/cultivar which were grown at Pang Da Royal Agricultural Station

Line/ Cultivar	Number of days (days)			First flowering node[1/]	Flower color	Pod characteristic	Consumption part
	First flowering[1/]	First blooming[1/]	First pod setting[1/]				
P117	34.73 e	37.80 d	42.07 d	22 b	White	Green round pod	Seed edible
P185	39.40 b	41.93 c	46.33 c	22 b	White	Green round pod	Seed edible
P309	41.60 a	45.80 a	56.00 a	25 a	White	Green inflated pod	Pod
No.3	38.80 c	42.80 b	47.67 c	15 d	White	Green flated pod	Pod
No.4	33.93 f	37.87d	41.93 d	17 c	White	Green flated pod	Pod
No.5	27.93 g	30.60 e	34.67 f	13 f	White	Green flated pod	Pod
Fang No.7	36.00 c	37.87d	40.73 e	16 d	Purple	Green flated pod	Pod
$LSD_{0.05}$	0.32	0.35	0.77	0.52			
CV (%)	0.49	0.51	1.98	0.59			

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

4.1.1.2 Flowering node

Flowering node defined as the stem node number at which the first flower is initiated (the cotyledonary node being assigned the number 0) (Muehlbauer, 1997). Floral initiation begins at the lowest flowering node and proceeds sequentially up the vines. One or more nodes may bear flowers, depending upon the genotype and

environmental condition (Gritton, 1986). The first flowering node of each lines/cultivar was recorded. The results showed that the lowest first flowering node was found in line No.5 at the 13rd node whereas first flower of other lines/cultivar appeared at higher nodes. For line No.3, the first flower appeared at the 15th node. Meanwhile, the first flower of cultivar Fang No.7 and line No.4 were found at the 16th and 17th node, respectively. Lines P117 and P185, both showed the first flowering on the 22nd node. The highest at which flower initiation occurred, was shown in line P309 at the 25th node (Table 4.1).

4.1.2 Pod development

4.1.2.1 Pod setting

The study showed that the first pod setting of line No.5 was earlier than those of others, it took only 34.67 days followed by cultivar Fang No.7, lines No.4 and P117 that number of days of first pod setting were 40.73, 41.93 and 42.07 days, respectively, while two lines, P185 and No.3, had the average number of days at 46.33 and 47.67 days, respectively. In addition, the latest of first pod setting was found in line P309 which had an average number of days at 56.00 days. However, the shortest duration from the flower bud to pod size reached 1.0 cm was found in cultivar Fang No.7 which had an average of 5 days whereas line P309 had the longest development duration with an average of 14 days. The number of days of other lines/cultivar varied from 7 to 9 days (Table 4.1).

4.1.2.2 Pod Characteristics

Pod characteristics of snow pea are generally classified into 2 groups depending on types of consumption. The first type is an edible fresh seed or seed for

processing or canned, their pod characters are green round pod, large round seed, tough shell and more fiber whereas the other type is an edible fresh pod, very popular for consumption, which has various pod types such as flat and round, soft and crisp, and pod color is green. In this study, pod characteristics of 7 snow pea lines/cultivar were classified following the consumption type data as mentioned above. The result showed lines P117 and P185 were classified into edible fresh seed or suitable for processing while lines No.3, No.4, No.5 and cultivar Fang No.7 had pod characteristics as flat green, wide wing and slightly softened pods, which was classified as an edible fresh pod pea. Whereas, pod characteristics of line P309 were classified into the second group but its pod slightly different in shape from the standard which was inflated pods, crisp and slightly tough shell (Figure. 4.2).

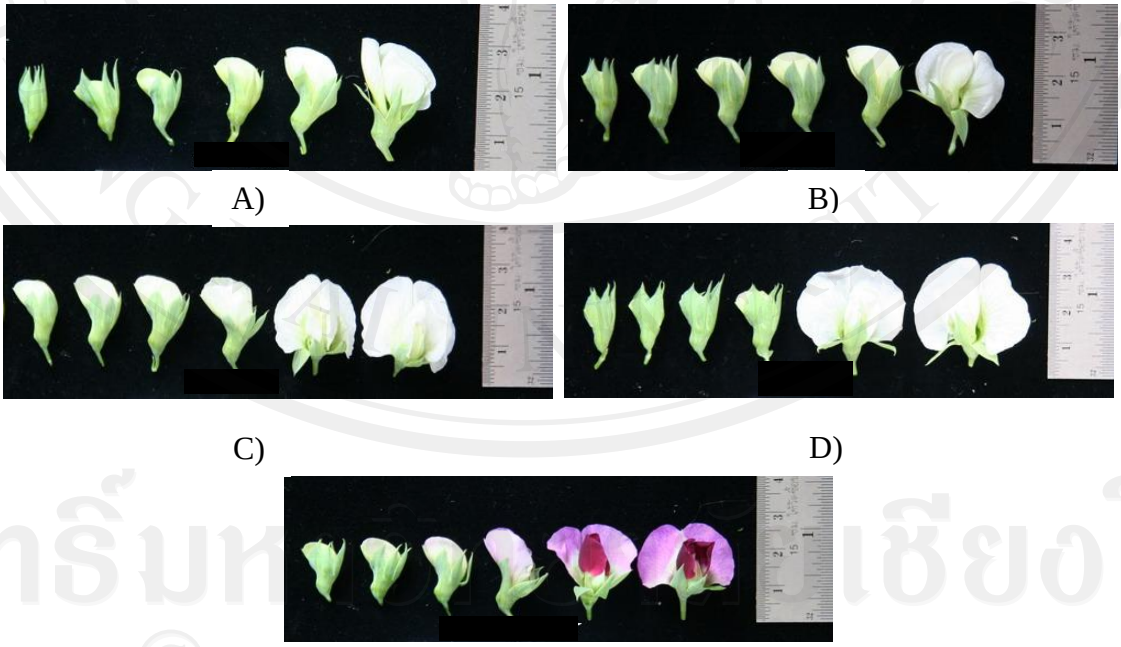


Figure 4.1 Flower characteristics of pea lines/cultivar A) P117 B) P185 C) P309 D) No.5 and E) Fang No.7.

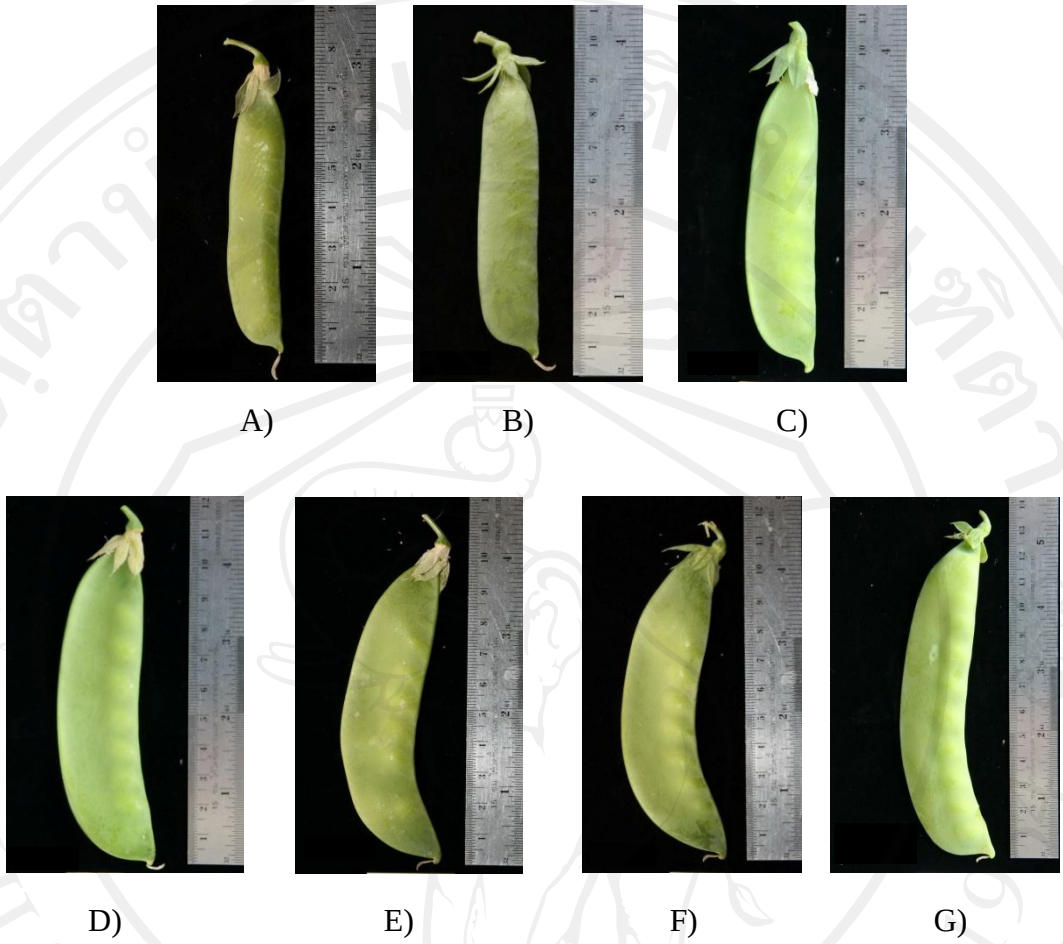


Figure 4.2 Pod characteristics of 7 pea lines/cultivar A) P185 B) P117 C) P309 D) No.3 E) No.4 F) No.5 G) Fang No.7.

4.1.3 Plant growth

4.1.3.1 Vine heights

Pea vines, usually single, is slender and upright. However, more than one stems may be found if the apical growing point is destroyed (Gritton, 1986). In this study, vine height was measured on the main stem, starting from the basal of the plant to the shoot apex. At 120 days after transplanting, the results showed that line P185 gave the tallest vines with an average of 213.10 cm followed by cultivar Fang No.7, lines P309 and No.5 with an average of 189.93, 175.03 and 113.43 cm,

respectively, while the average vine height of lines No.3 and No.4 was not significantly different. The shortest average vine height was found in line P117 at 60.1 cm (Table 4.2).

4.1.3.2 The number of node and branches

The first nodes above the cotyledonary node, where the lower scale leaf develop, is considered 1st node. The upper scale leaf node is counted as node two, and so on up along the vine (Gritton, 1986). The total number of nodes per plant was counted at 120 days after transplanting. The result showed that the greatest number of nodes per plant found in line P185 with an average of 31.47 nodes followed by line P309 at 27.63 nodes. Line No.3 and cultivar Fang No.7 were not significant with an average, 21.50 and 23.43 nodes, respectively. The least average number of nodes was found in lines No.5 and No.4 at 14.23 and 15.03 nodes, respectively. Generally, axillary branches from various nodes rapidly occur when apical dominance or growing point is destroyed. Two rudimentary or primary scales or leaves are formed immediately above the cotyledonary node and these may be found above or below the soil surface (Gritton, 1986). The number of branches which occurred at plant basal were recorded and it was found that line P185 had the greatest number of branches with an average of 9.50 branches per plant, followed by cultivar Fang No.7, lines No.3, P117 and P309, with the average 4.80, 4.70, 4.23 and 4.20 branches, respectively. The least number of branches was lines No.5 and No.4 at 2.40 and 3.07 branches, respectively (Table 4.2).

Table 4.2 Heights, nodes and branches number of 7 pea lines/cultivar

Line/cultivar	Height (cm.) [1/]	No. of Nodes[1/]	No. of branches[1/]
P117	60.13 f [1/-2/]	19.97 d	4.23 b
P185	213.10 a	31.47 a	9.50 a
P309	175.03 c	27.63 b	4.20 b
No.3	86.07 e	21.50 cd	4.70 b
No.4	83.23 e	15.03 e	3.07 c
No.5	113.43 d	14.23 e	2.40 c
Fang No.7	189.93 b	23.43 c	4.80 b
$LSD_{0.05}$	2.18	2.60	0.97
CV (%)	3.55	6.66	11.61

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

4.1.3.3 Pod length

(a) Length of fresh pod was recorded. The result showed that the longest pod length was found in line No. 3, cultivar Fang No.7 and line No.4 with an average of 10.74, 10.69 and 10.30 cm, respectively followed by line No.5 at 9.69 cm. The shortest pod length was found in line P185 with an average 6.68 cm (Table 4.3).

(b) Length of dry pod of 7 snow pea lines/cultivar was recorded when the pod turned to brown. After measurement, dried pod of cultivar Fang No.7 and line P309 showed the longest average with 10.66 and 10.19 cm, respectively followed by lines No.4 and No.3 with the average 9.87 and 9.59 cm, respectively while the shortest average pod length was found in line P185 with an average of 6.37 cm (Table 4.3).

4.1.3.4 Pod width

(a) The width of fresh pod was measured at the middle of pea pod. The result showed line No.4 had the widest pod width with an average of 2.84 cm. Pod width of cultivar Fang No.7 and line No.5 was not statistically different with an

average of 2.58 and 2.51cm, respectively. Meanwhile pod width of line P309 was 2.21 cm. The smallest pod width was found in lines P117 and P185 with an average of 1.66 and 1.69 cm, respectively (Table 4.3).

(b) The biggest dry pod width was found in line No.4 with an average 2.68 cm. Cultivar Fang No.7 had pod width of 2.32 cm. The smallest pod width was found in lines P185 and P117 with an average of 1.38 and 1.49 cm, respectively (Table 4.3).

4.1.3.5 Number of seeds per pod

The average number of seeds per pod of each line/cultivar was recorded at the stage that the pod color turned to be brown and dry. Result of seed counting showed that cultivar Fang No.7, lines P309 and No.4 had the highest number of seeds per pod with an average 7.35, 6.93 and 6.70 seeds, respectively. The least number of seeds per pod were found in lines No.5 and No. 3 with an average of 4.50 and 5.25 seeds per pod, respectively (Table 4.3).

Table 4.3 Length, width of fresh and dry pod, number of seeds per pod of 7 pea lines/cultivar

Line/cultivar	Pod length (cm)		Pod width (cm)		Seeds per pod[1/]
	Fresh pod[1/]	Dry pod[1/]	Fresh pod[1/]	Dry pod[1/]	
P117	8.00 c	7.67 d	1.66 e	1.49 e	6.55 ab
P185	6.68 d	6.37 e	1.69 e	1.38 e	5.43 cd
P309	8.55 c	10.19 ab	2.21 d	1.84 c	6.93 a
No.3	10.74 a	9.59 b	2.47 c	1.70 d	5.25 de
No.4	10.30 ab	9.87 b	2.84 a	2.68 a	6.70 ab
No.5	9.69 b	8.14 c	2.58 b	1.72 cd	4.50 e
Fang No.7	10.69 a	10.66 a	2.51 bc	2.32 b	7.35 a
$LSD_{0.05}$	0.78	0.76	0.1	0.14	0.81
CV (%)	5.94	5.99	3.26	5.17	8.98

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

4.2 Phenotypic evaluation of powdery mildew resistance

Seven pea lines/cultivar were evaluated for powdery mildew resistance, caused by *Oidium* sp., in two conditions, field and greenhouse. The results of each condition were as follows;

4.2.1 Field evaluation

The experiment was conducted in the field at Pang Da Royal Agricultural Station. The disease infection on leaf surface area at the 4th, 7th, 10th nodes and a whole plant at 45, 55, 65 and 75 days, respectively, were evaluated. The result of each node showed as follows.

4.2.1.1 The 4th leaf node

The result showed the highest percentage of infected leaf surface area with powdery mildew found in lines No.4, No.5, No.3 and cultivar Fang No.7 was 62.1, 68.3, 85.1 and 100%, respectively. Whereas the infection on leaf surface area of

the other lines, P117, P185 and P309 were only 0.3, 0.8 and 1.9%, respectively (Figure 4.3A).

4.2.1.2 The 7th leaf node

At this stage, the highest percentage of infection on leaf surface area was found in line No.3 and cultivar Fang No.7 at 47.7 and 73.9 %, respectively. Whereas non-infected powdery mildew on the leaf surface area was found in lines P117, P185 and P309 (Figure 4.3 B).

4.2.1.3 The 11th leaf node

The evaluation of infected area on the leaf surface result showed the greatest average percentage of infection found in cultivar Fang No.7 was 96.0%, followed by lines No.4, No.3 and No.5 at 32.4, 48.5 and 56.6%, respectively. Meanwhile, the least amount of infection was found in lines P117, P309 and P185 at 4.5, 4.9 and 10.9 %, respectively (Figure 4.3 C).

4.2.1.4 The whole plant evaluation

The final check was evaluated the disease infection on a whole plant. The result showed that cultivar Fang No.7 and line No.3 were significantly infected with an average 90.0 and 60.4%, respectively, followed by lines No.5 and No.4 at 50.2 and 37.8%, respectively. Meanwhile, lines P117, P309 and P185 had the least percentage of infection of powdery mildew at 1.6, 2.3 and 3.9 %, respectively (Figure 4.3 D).

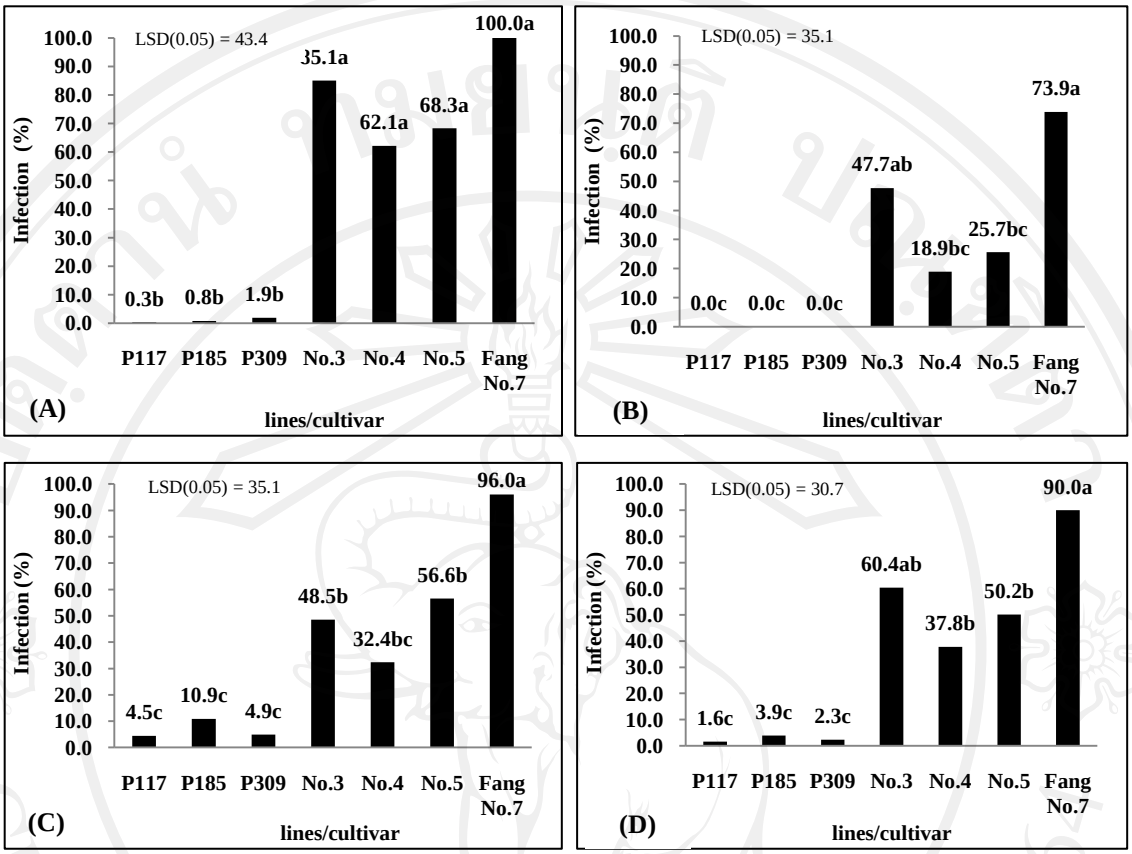


Figure 4.3 Powdery mildew infection percentage on leaf surface area at various node positions in 7 pea lines/cultivar which was conducted in the field condition at Pang Da Royal Agricultural Station in winter season during November 2006 to March 2007.

A) At the 4th leaf node

B) At the 7th leaf node

C) At the 11th leaf node

D) A whole plant.

Figure 4.4 Powdery mildew resistance evaluation of 7 pea lines/cultivar at 65 day after transplanting, in the field condition at Pang Da Royal Agricultural Station in winter season during November 2006 to March 2007.

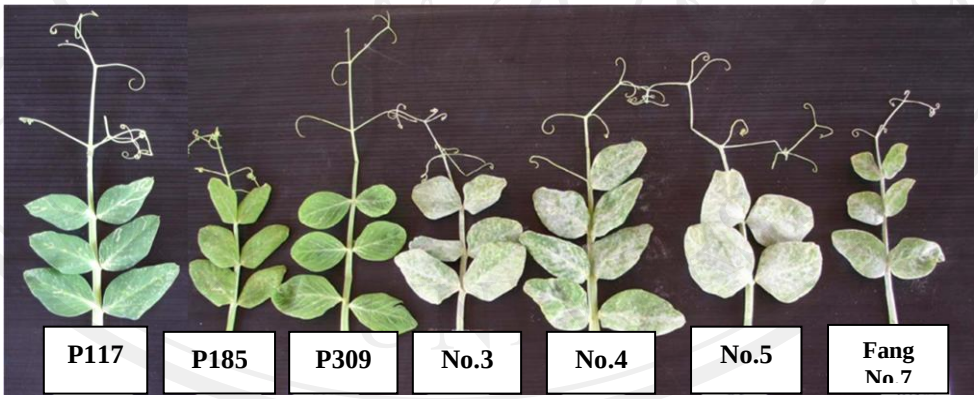


Figure 4.5 Powdery mildew disease infections on pea leaves at the 11th node of 7 pea lines/cultivar at 65 days after transplanting which was conducted in field condition at Pang Da Royal Agricultural Station in winter season during November 2006 to March 2007.

4.2.2 Greenhouse condition

The evaluation of powdery mildew resistance on the leaf surface area of 7 pea lines/cultivars was taken under greenhouse condition at Inthanon Station in rainy season during August to October 2008. In this experiment, the leaf surface areas on the 7th, 11th and a whole plant were recorded for the incidence of infection. In this study, at 45 days after transplanting, the 4th leaf node was checked. There was no symptom of powdery mildew infection. Therefore, no evaluation was done at this stage.

4.2.2.1 The 7th leaf node

At this stage, lines No.5, No.4, cultivars Fang No.7 and line No.3 showed the percentage of infection at 6.5, 7.4, 8.3 and 15.0%, respectively whereas the infected symptom of line P309, P117, and P185 were less than line No.4 at 3.2, 3.4 and 3.7%, respectively (Figure 4.6 A).

4.2.1.2 The 11th leaf node

At 55 days after transplanting, the result showed that the percentage of infected rate on leaf surface area on the 11th node of 7 pea lines/cultivar was not significantly different which ranged between 7.5 to 18.8%. (Figure 4.6 B)

4.2.1.3 The whole plant evaluation

The disease infection was evaluated on a whole plant as final check. The result showed that lines P185, No.5, No.3, No.4, and cultivar Fang No.7, had similar amount of infection at 77.9, 82.6, 84.0, 88.4, and 92.1%, respectively, whereas the infection percentage of line P309 was less than cultivar Fang No.7 and line No.4 at 70.6%. Line P117 had the least infection at 64.3 % when compared with lines No.3, No.4, No.5, and cultivar Fang No.7 (Figure 4.6 C).

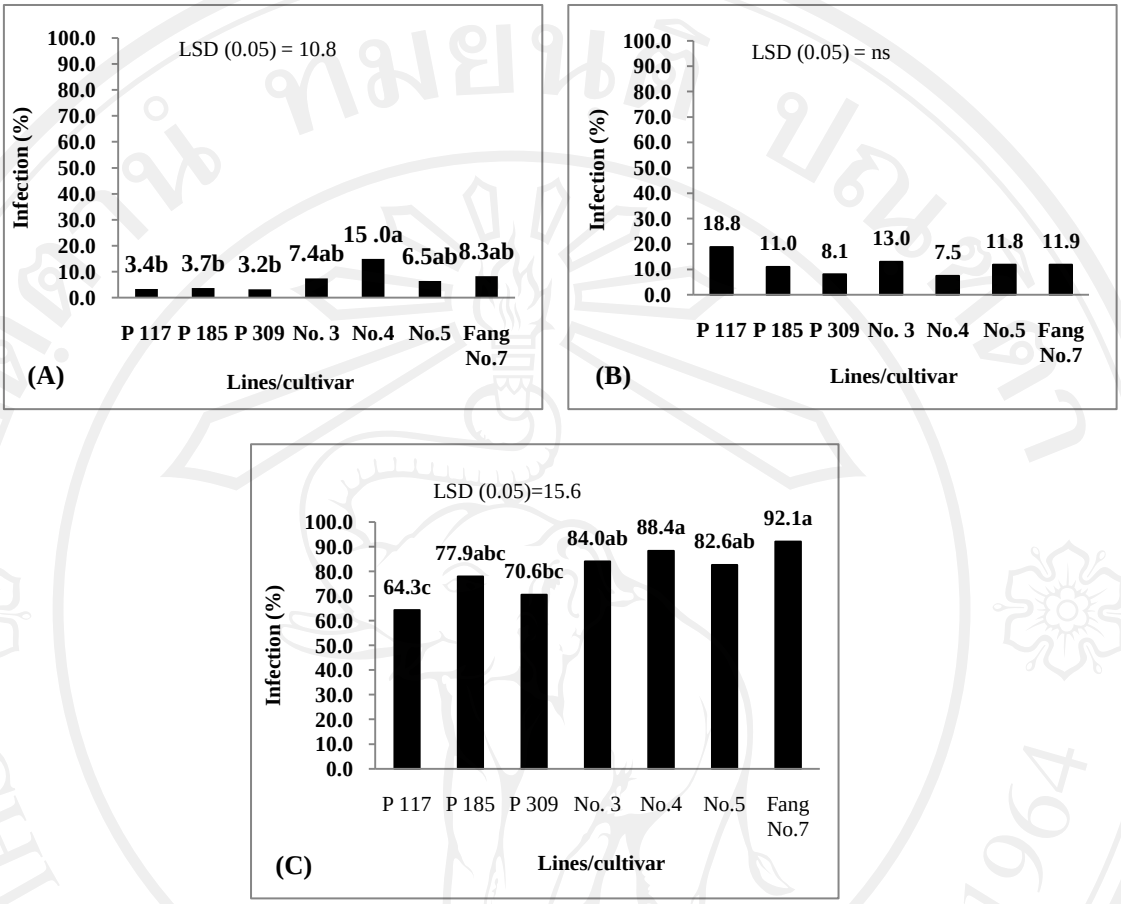


Figure 4.6 Powdery mildew infection percentage on leaf surface area at various node positions in 7 pea lines/cultivar which was conducted under the greenhouse at Inthanon Royal Agricultural Research Station in rainy season during August to October 2008.

A) At the 7th leaf node

B) At the 11th leaf node

C) A whole plant.

Figure 4.7 Powdery mildew resistance evaluation plot of 7 pea lines/cultivar at 30 days after transplanting, under greenhouse condition at Inthanon Royal Agricultural Research Station during August to October 2008.

Figure 4.8 Powdery mildew resistance evaluation plot of 7 pea lines/cultivar at 75 days after transplanting, under greenhouse condition at Inthanon Royal Agricultural Research Station during August to October 2008.

4.3 DNA marker linked to powdery mildew resistance in snow pea

DNA of 7 pea lines/cultivar, 3 powdery mildew resistant lines, P117, P185 and P309 and 4 powdery mildew susceptible lines/cultivar, No.3, No.4, No.5, and Fang No.7, were extracted from young leaves using DNAzol reagent. After that, genomic DNA was kept for further experiments.

4.3.1 Suitable primer screening

Three primers, OPU-17, OPO-02 and ScOPD-10 were used to amplify DNA in PCR reaction. It was found that all 3 primers generated multiple DNA bands from each sample. However, primer ScOPD-10 produced a total of 13 DNA bands (Table 4.4) and yielded 850 bp. DNA markers only in the powdery mildew resistant lines, but not in the powdery mildew susceptible lines/cultivar (Figure 4.9). The primers OPU-17 and OPO-02 produced a total of 6 and 8 DNA bands, respectively (Figure 4.10, 4.11) (Table 4.5, 4.6). However, both primers did not detect any DNA marker which could distinguish the resistant group from the susceptible group.

Table 4.4 DNA bands of 7 snow pea lines/cultivar generated by SCAR primer ScOPD-10

No.	bp.	P117	P185	P309	No. 3	No. 4	No.5	Fang No.7
1	2000	0	0	0	1	0	1	1
2	1800	0	0	0	1	0	1	1
3	1300	1	1	1	1	1	0	1
4	1200	1	1	1	1	1	1	1
5	950	1	1	1	1	1	1	1
6	850	1	1	1	0	0	0	0
7	700	1	1	1	1	1	1	1
8	650	1	1	1	1	1	1	1
9	450	1	1	0	0	0	1	1
10	400	1	1	1	1	1	1	1
11	310	1	1	1	1	1	1	1
12	200	0	0	1	1	1	1	0
13	150	1	1	1	0	1	1	1

Remark 1=presence band, 0=absence band

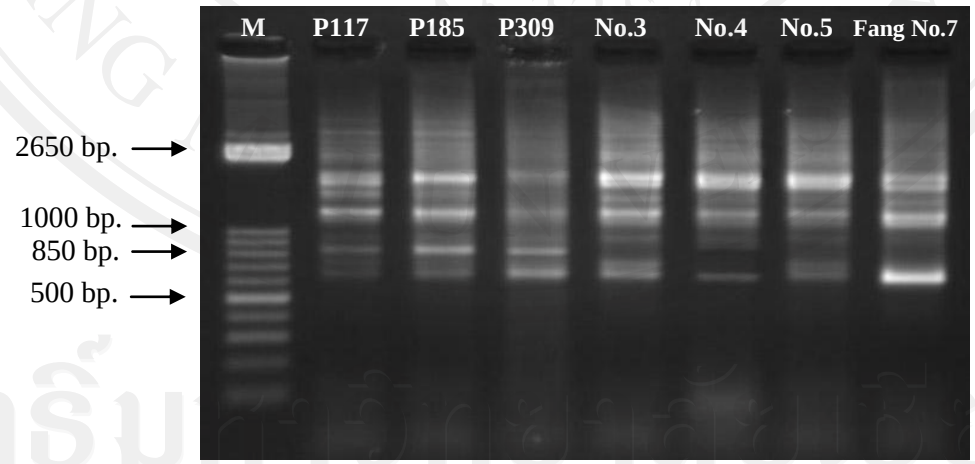


Figure 4.9 PCR profiles of 7 snow pea lines/cultivar, 3 of powdery mildew resistant lines, P117, P185 and P309, and 4 of powdery mildew susceptible lines/cultivar, No.3, No.4, No.5 and Fang No.7, amplified by SCAR primer ScOPD-10.

Table 4.5 DNA bands of 7 snow pea lines/cultivar generated by random primer OPU-17

No.	bp.	P117	P185	P309	No. 3	No. 4	No.5	Fang No.7
1	1200	0	0	0	1	0	0	1
2	850	1	1	1	1	1	1	1
3	800	0	0	0	1	0	0	1
4	700	0	1	0	0	0	0	1
5	600	1	1	1	1	1	1	1
6	550	0	1	0	0	0	0	0

Remark 1=presence band, 0=absence band

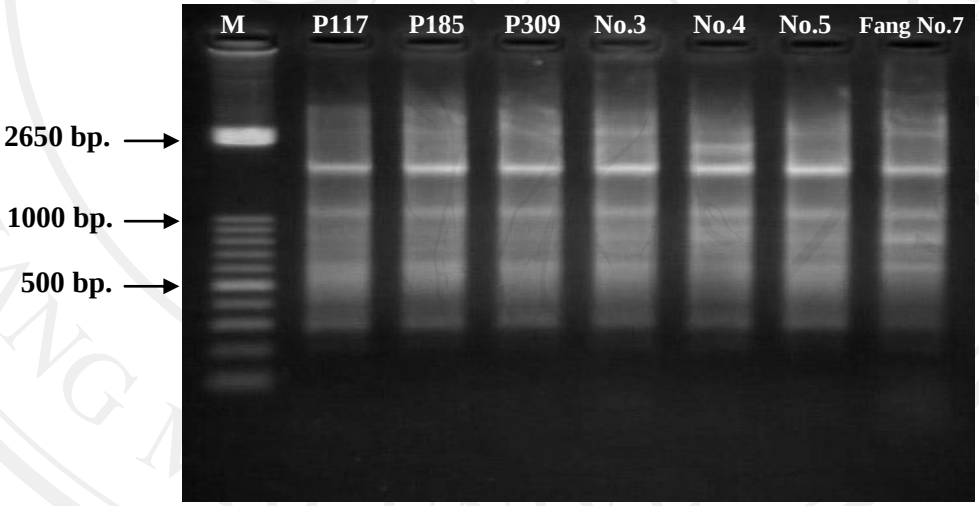


Figure 4.10 PCR profiles of 7 snow pea lines/cultivar, 3 of powdery mildew resistant lines, P117, P185 and P309, and 4 of powdery mildew susceptible lines/cultivar, No.3, No.4, No.5 and Fang No.7, amplified by random primer OPU-17.

Table 4.6 DNA bands of 7 snow pea lines/cultivar generated by random primer OPO-02

No.	bp.	P117	P185	P309	No. 3	No.4	No.5	Fang No.7
1	2300	1	1	1	1	1	1	1
2	1400	1	1	1	1	1	1	1
3	1200	0	0	0	0	0	0	1
4	900	1	1	1	0	0	0	0
5	850	1	1	1	1	1	1	1
6	800	1	0	0	0	0	0	0
7	450	1	1	1	1	1	1	1
8	300	0	0	0	1	1	1	1

Remark 1=presence band, 0=absence band

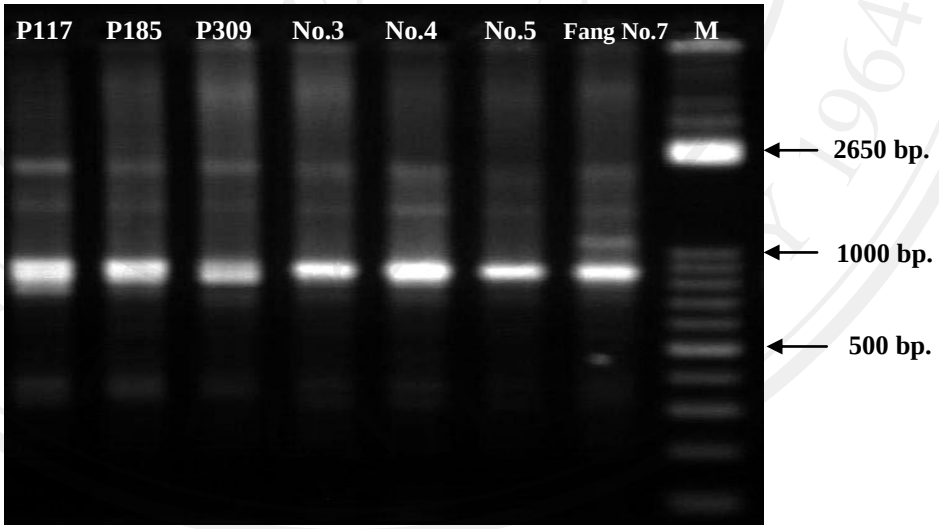


Figure 4.11 PCR profiles of 7 snow pea lines/cultivar, 3 of powdery mildew resistant lines, P117, P185 and P309, and 4 of powdery mildew susceptible lines/cultivar, No.3, No.4, No.5, and Fang No.7, amplified by random primer OPO-02.

4.3.2 Sequencing of the specific SCAR marker (850 bp.)

The 850-bp., fragments, amplified by SCAR primer ScOPD10, were found in 3 powdery mildew resistant lines, P117, P185 and P309. The sequencing of the fragments revealed 618, 621, and 624 bases, respectively. DNA sequences were compared with DNA sequences database at National Center for Biotechnology Information (NCBI) GenBank. After BLAST searches of the sequences, the 618-, 621-, and 624- base sequences showed 91, 90, and 91% homology, respectively, to complete sequence of *P. sativum* (Table 4.7, Figure 4.12-4.14).

Table 4.7 Description of three specific bands comparing with NCBI database

Lines	Bases	Accession	Description	Query Coverage
P117	618	CU655881.10	*P. sativum* DNA sequence from clone JICPSV-598E15, complete sequence	91%
P185	621	CU655881.10	*P. sativum* DNA sequence from clone JICPSV-598E15, complete sequence	90%
P309	624	CU655881.10	*P. sativum* DNA sequence from clone JICPSV-598E15, complete sequence	91%

TAAAAATTGAAATACTCAACAGCTCAATATGCATGAATGATGAATTAAAGAACTTCCCTTG
ATTGTATTTGAGCAAAGGTTGAGGTTTCTTCATGAGCAAGGCACAATTGATACATAGATGA
ATTAGGGTTTCCTTGGGAAACAAGCCTCAAACCCTTTGGTTTGGTTTGATCAAAACGATGA
ATTGAGATACTTGGGAGGCATATTTGATGGATTAGAGATTTGGGAACCATTGCCATGCTTT
CTTTCATCTTCTCTTGGCTATATCAATGCACATAGGATCTCCTAGAAGCTTTGGACCTTATG
ACTGTTCAAGCTACAAACAAAAGATGTTAGTGACATATTTTTATGCTTTTGGTTAGTGAAT
AAAAAATGAGAAAAGAAATAATATACAATTTAAGCATGCTTTGTGATCTCAAACCAACTC
TCAAAAGATCCCACCCTAGGGTAAGAGCCAAGATGCTTATGATCCTTAAGGCAAGATGCA
AATGCAATGTTATGATGCCATGAGGGATCTTAGGGTCAAATAGGGGTCTTACAGTATGTTC
GAGCATGCGATATGTTCGGGTATATTTTCGCTAGCTTCACGGACATAGTACGGACACTGTT
TAGGTGTAGACCATAT

Figure 4.12 DNA sequence of the specific band of line P117.

CTTACAATTATTCGAATCGAGAGCTCCAACTTCTGCAATTCTAGGCTCTGGGTTTGGGTTG
GGGGTGCTCCTGTCGTGCAACGGATATACATGAGCAAGGCACAATTGATACATAGATGAA
TTAAGGTTTCCCTGGGAAACAAGCCTCAAACCCTTTGGTTTGGTTTGATCAAAACGATGAA
TTGAGATACTTGGGAGGCATATTTGATGGATTAGAGATTTGGGAACCATTGCCATGCTTTC
TTTCATCTTCTCTTGGCTATATCAATGCACATAGGATCTCCTAGAAGCTTTGGACCTTATGA
CTGTTCAAGCTACAAACAAAAGATGTTAGTGACATATTTTTATGCTTTTGGTTAGTGAATA
AAAAATGAGAAAAGAAATAATATACAATTTAAGCATGCTTTGTGATCTCAAACCAACTCT
CAAAAGATCCCACCCTAGGGTAAGAGCCAAGATGCTTATGATCCTTAAGGCAAGATGCAA
ATGCAATGTTATGATGCCATGAGGGATCTTAGGGTCAAATAGGGGTCTTACAGTATGTTCG
AGCATGCGATATGTTCGGGTATATTTTCGCTAGCTTCACGGACATAGTACGGACACTGTTT
AGGTGTAGACCA

Figure 4.13 DNA sequence of the specific band of line P185.

CGTAAAACACGAGTCTCAACAGTTCAATATGCATGAAATGATGAATTAAAGAACTTCCCTT
GATTGTATTTGAGCAAAGGTTGAGGTTTCTTCATGAGCAAGGCACAATTGATACATAGATG
AATTAGGGTTTCCTTGGGAAACAAGCCTCAAACCCTTTGGTTTGGTTTGATCAAAACGATG
AATTGAGATACTTGGGAGGCATATTTGATGGATTAGAGATTTGGGAACCATTGCCATGCTT
TCTTTCATCTTCTCTTGGCTATATCAATGCACATAGGATCTCCTAGAAGCTTTGGACCTTAT
GACTGTTCAAGCTACAAACAAAAGATGTTAGTGACATATTTTTATGCTTTTGGTTAGTGAA
TAAAAAATGAGAAAAGAAATAATATACAATTTAAGCATGCTTTGTGATCTCAAACCAACT
CTCAAAAGATCCCACCCTAGGGTAAGAGCCAAGATGCTTATGATCCTTAAGGCAAGATGC
AAATGCAATGTTATGATGCCATGAGGGATCTTAGGGTCAAATAGGGGTCTTACAGTATGTT
CGAGCATGCGATATGTTCGGGTATATTTTCGCTAGCTTCACGGACATAGTACGGACACTGT
TTAGGTGTAGACCA

Figure 4.14 DNA sequence of the specific band of line P309.

4.4 Hybridization for powdery mildew resistance

4.4.1 Crossing and selection

F_1 hybrid plants of 23 crosses were observed and evaluated. All crosses had pod characters similar to resistant parent. Only pod type of F_1 hybrids that derived from line P309 which was used as male and female parents were closed to snow pea pod type, semi flatted pod, while pod type of other crosses which used lines P117 and P185 as both male and female parents, was round pod, more fiber and could be grouped into edible for young seed consumption (Figure 4.15). Then, only four F_1 hybrids, No.3 × P309, P309 × No.4, No.5 × P309 and Fang No.7 × P309, which were obtained the resistant gene from line P309, were used as a plant material for the further breeding program by backcrossing method.

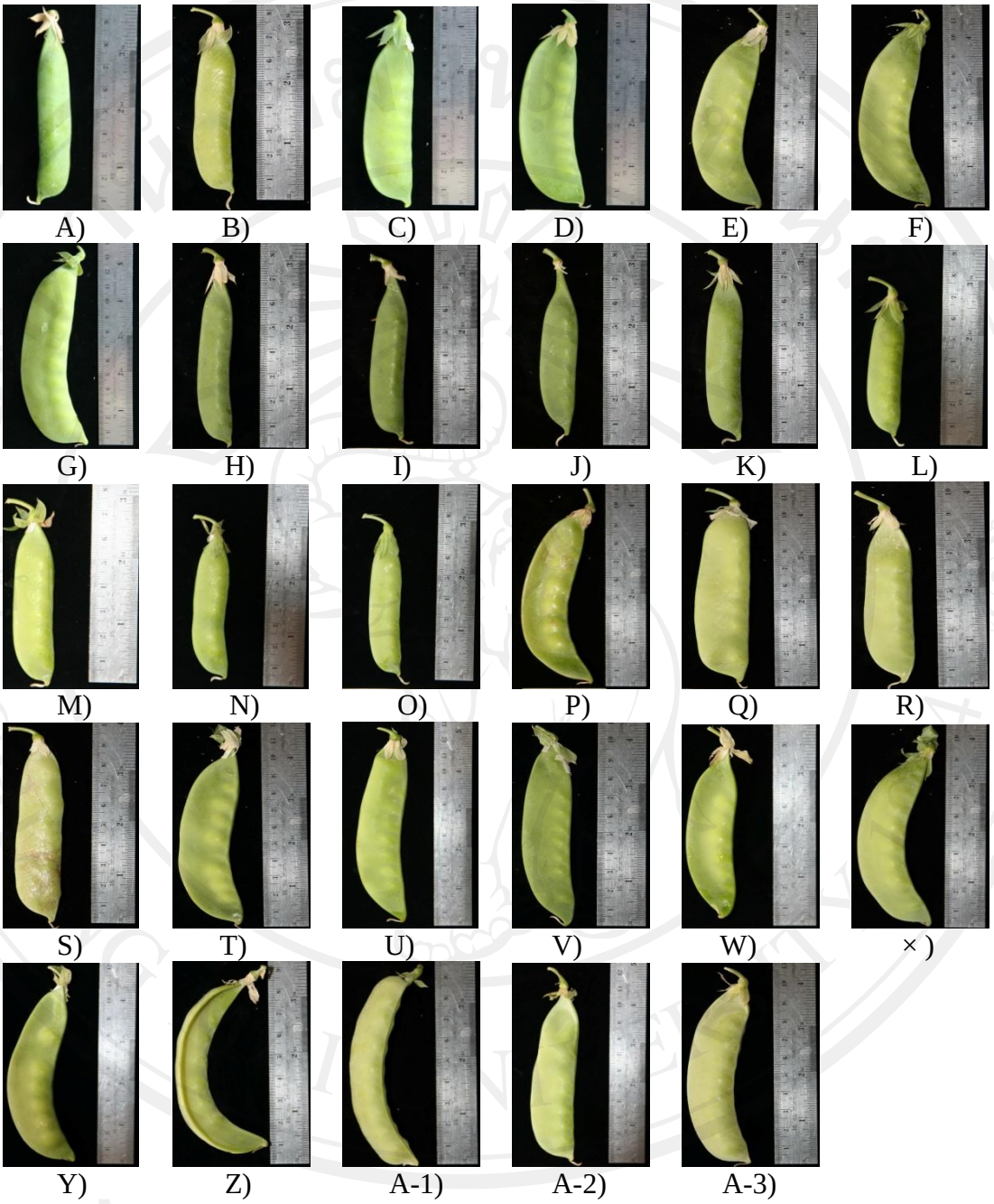


Figure 4.15 Pod characteristics of F_1 hybrid derived from different crosses

A) P117 B) P185 C) P309 D) No.3 E) No.4 F) No.5 G) Fang No.7 H) P117 × No.3 I) P117 × No.4 J) P117 × No.5 K) P117 × Fang No.7 L) P185 × No.3 M) P185 × No.4 N) P185 × No.5 O) P185 × Fang No.7 P) P309 × No.3 Q) P309 × No.4 R) P309 × No.5 S) P309 × Fang No.7 T) No.3 × P117 U) No.3 × P185 V) No.4 × P117 W) No.4 × P185 X) No.5 × P117 Y) No.5 × P185 Z) No.5 × P309 A-1) Fang No.7 × P117 A-2) Fang No.7 × P185 and A-3) Fang No.7 × P309

4.4.2 Backcrossing

Four crosses of F_1 hybrids which had good horticultural characteristics similar to snow pea type, No.3 × P309, P309 × No.4, No.5 × P309 and Fang No.7 × P309, were selected for backcrossing to recurrent parents at Pang Da and Inthanon Station. Three backcross generations, BC_1, BC_2 and BC_3 in this current study, line P309 which contained resistant character, was used as female parent instead of commercial lines No.3, No.4, No.5, and cultivar Fang No.7, the susceptible lines/cultivar, due to these lines/cultivar were heavily infected from powdery mildew disease and hybridized flowers could not develop to pod. Then, four generations of hybrid, F_2, BC_1F_2, BC_2F_2, and BC_3F_2 were evaluated for phenotypic of powdery mildew resistance under greenhouse condition. Due to heavy disease severity, scoring by using visual evaluation could not distinguish the difference between resistant and susceptible plants. Thus, the visual evaluation was conducted based on the presence of disease on the basal stem. The resistant plant had no infection on the basal stem whereas the susceptible one had infection on the basal stem (Figure 4.16) Those plants with showed no sign of infection at the basal stem were selected and rechecked for resistance using DNA marker (Table 4.8)

Figure 4.16 Evaluation of resistance by using snow pea stem character; A) resistant to powdery mildew disease and B) susceptible to powdery mildew disease

4.4.3 Lingkage detection of powdery mildew resistance in snow pea hybrids

The SCAR primer, ScOPD-10, was used to amplify the specific SCAR marker, at 850 bp. Resistant plants of four F_2 generations, F_2, BC_1F_2, BC_2F_2, BC_3F_2, derived from crosses No.3 × P309, P309 × No.4, No.5 × P309 and Fang No.7 × P309 as well as parents, were randomly tested for the presence of DNA marker linked to powdery mildew resistance.

4.4.3.1 F_2 hybrid

It was found that banding pattern of specific SCAR marker of cross No.3 × P309 was found in male parent, line P309, and 7 plants of F_2 hybrid (Figure 4.17). This result was similar to that of cross P309 × No.4. The female parent, line P309, and 7 plants of F_2 hybrids showed the specific SCAR marker (Figure 4.18). The marker appearance percentage in both crosses was 70% whereas in cross of Fang No.7 × P309, specific SCAR marker was found in male parent, line P309, and 16 plants of F_2 hybrid (Figure 4.19). The marker appearance percentage was 84.2% (Table 4.8).

4.4.3.2 The 1st backcross (BC_1)

The result was found that banding pattern of SCAR marker was found in male and female parents, line P309, and all plants of F_2 hybrid of four crosses derived from No.3 × P309, P309 × No.4 No.5 × P309 and Fang No.7 × P309 while specific SCAR marker was not found in female parent, lines No.3, No.5 and cultivar Fang No.7, and male parent, line No.4 (Figure 4.20-4.23). The marker banding appearance percentage of all four crosses was 90-100% (Table 4.8).

4.4.3.3 The 2nd backcross (BC_2)

In this generation, the specific SCAR markers of only 2 crosses, No.3 × P309, P309 × No.4, were amplified while other crosses, No.5 × P309 and Fang No.7 × P309, were heavily infected by the powdery mildew. All young leaves were covered by the white spore and mycelium. Therefore, the young leave could not be collected for DNA extraction. The results of these 2 crosses showed that the 850 bp. SCAR marker was found in male and female parent, line P309, and all plants of F_2 hybrids but it was not found in female parent, line No.3, and male parent, line No.4 (Figure 4.24-4.25). The marker appearance percentage of two crosses hybrids was 100% (Table 4.8).

4.4.3.4 The 3rd backcross (BC_3)

It was found that the specific SCAR marker of cross No.3 × P309 was found in male parent, line P309, and all plants of BC_3F_2 hybrid (Figure 4.26). In cross P309 × No.4, the female parent, line P309, and 7 plants of BC_3F_2 hybrids showed the specific SCAR marker. The marker appearance percentage of hybrids was 70% (Figure 4.27). The result in cross No.5 × P309 showed that banding pattern of specific SCAR marker was found in male parent, line P309, and 9 plants of BC_3F_2 hybrid (Figure 4.28). The marker appearance percentage of hybrid was 77.8%. Banding pattern of specific SCAR marker of cross Fang No.7 × P309 appeared in male parent, line P309, and 6 plants of BC_3F_2 hybrid (Figure 4.29). The marker appearance percentage of hybrids was 83.3% (Table 4.8).

Table 4.8 Evaluation of powdery mildew resistance by DNA marker

Crosses	generations	No. of selected PM resistant plants	No. of plants with specific 850-bp.	Resistance percentage (%)
No.3 × P309	F_2	10	7	70
	BC_1F_2	10	10	100
	BC_2F_2	10	10	100
	BC_3F_2	8	8	100
P309 × No.4	F_2	10	7	70
	BC_1F_2	10	9	90
	BC_2F_2	10	9	90
	BC_3F_2	10	7	70
No.5 × P309	F_2	*	*	*
	BC_1F_2	9	9	100
	BC_2F_2	*	*	*
	BC_3F_2	9	7	77.8
Fang No.7 × P309	F_2	19	16	84.2
	BC_1F_2	17	17	100
	BC_2F_2	*	*	*
	BC_3F_2	6	5	83.3

Remark: PM = powdery mildew disease

* The young leaves could not be collected due to heavily infected of powdery mildew on snow pea plant.

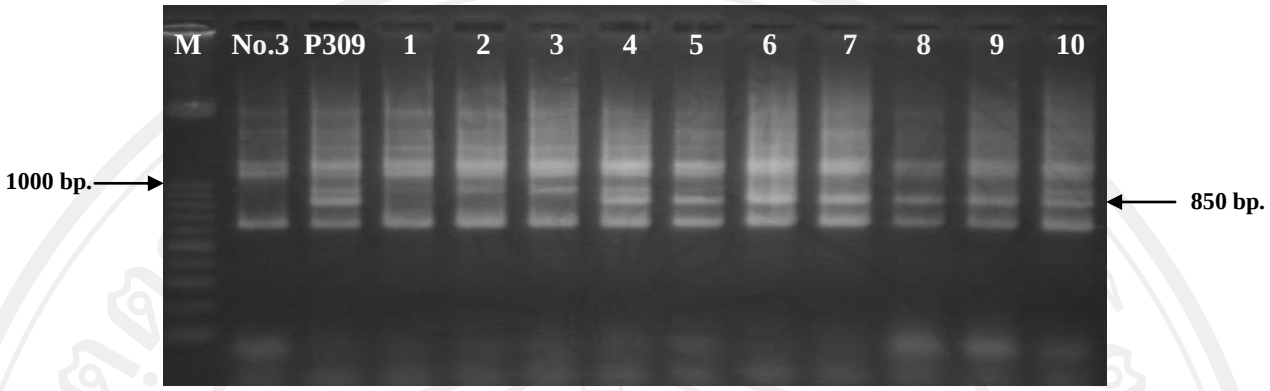


Figure 4.17 PCR profiles of line No.3 (female parent), line P309 (male parent), and their 10 powdery mildew resistant F_2 hybrids generated by SCAR primer ScOPD-10.

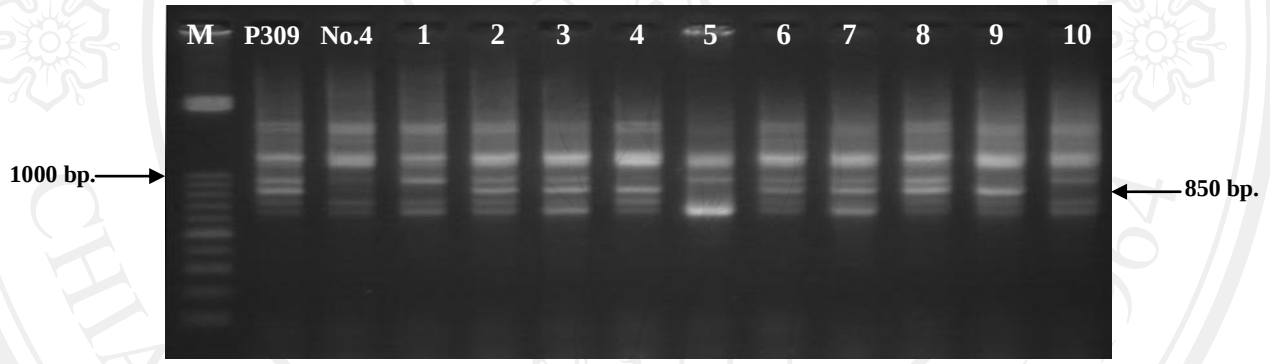


Figure 4.18 PCR profiles of line P309 (female parent), line No.4 (male parent), and their 10 powdery mildew resistant F_2 hybrids generated by SCAR primer ScOPD-10.

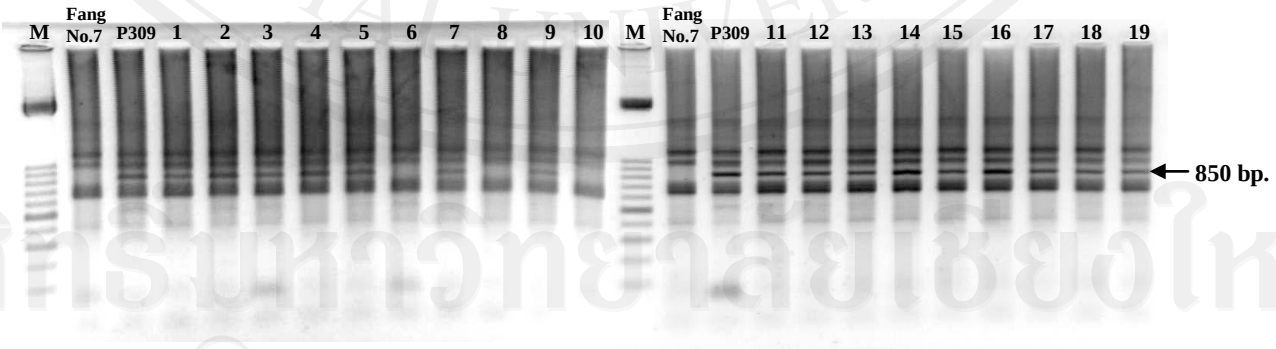


Figure 4.19 PCR profiles of cultivar Fang No.7 (female parent), line P309 (male parent), and their 19 powdery mildew resistant F_2 hybrids generated by SCAR primer ScOPD-10.

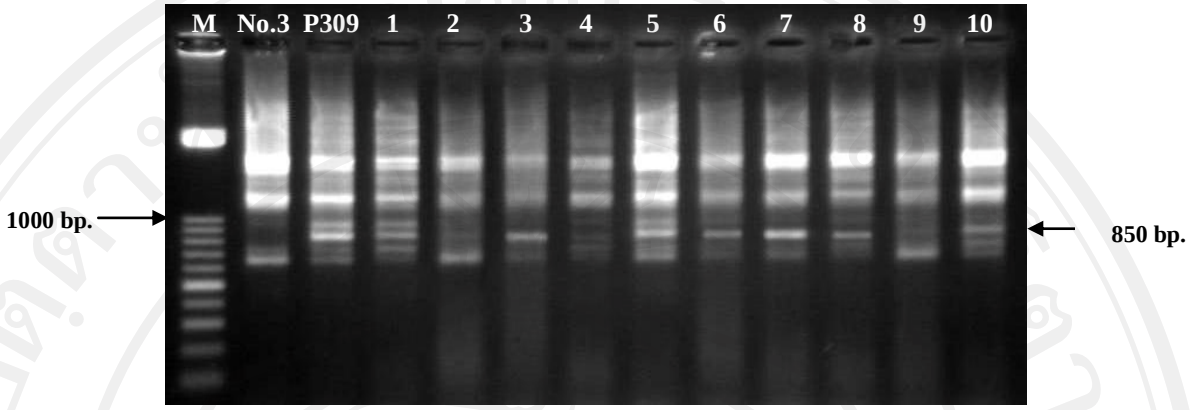


Figure 4.20 PCR profiles of line No.3 (female parent), line P309 (male parent), and their 10 powdery mildew resistant BC_1F_2 hybrids generated by SCAR primer ScOPD-10.

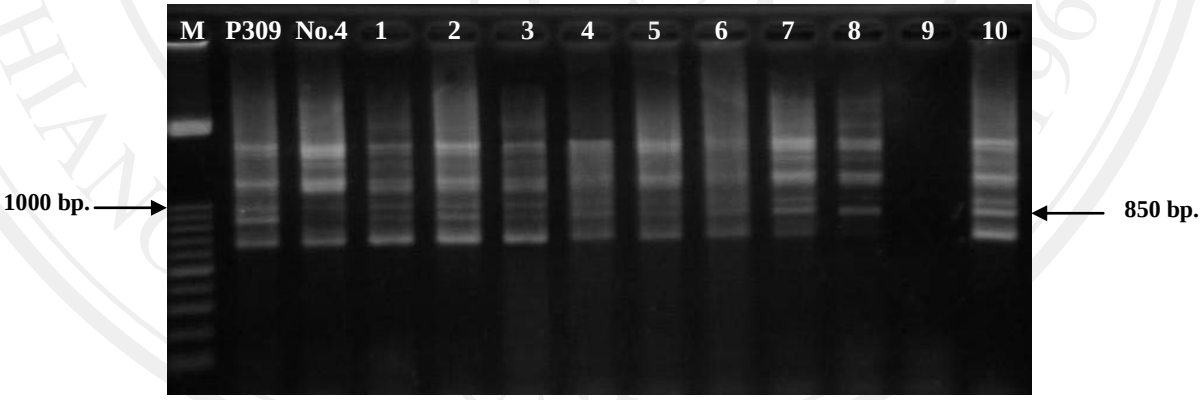


Figure 4.21 PCR profiles of line P309 (female parent), line No.4 (male parent), and their 10 powdery mildew resistant BC_1F_2 hybrids generated by SCAR primer ScOPD-10.

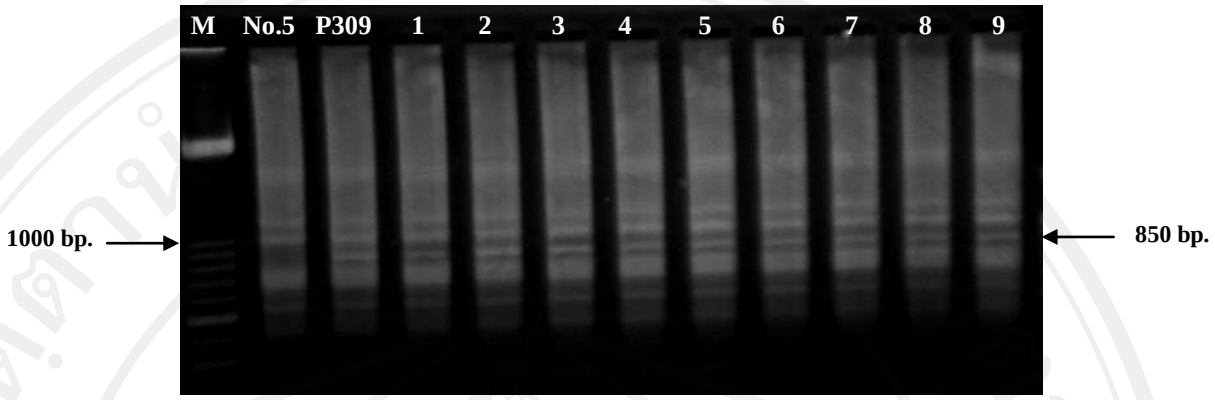


Figure 4.22 PCR profiles of line No.5 (female parent), line P309 (male parent), and their 9 powdery mildew resistant BC_1F_2 hybrids generated by SCAR primer ScOPD-10.

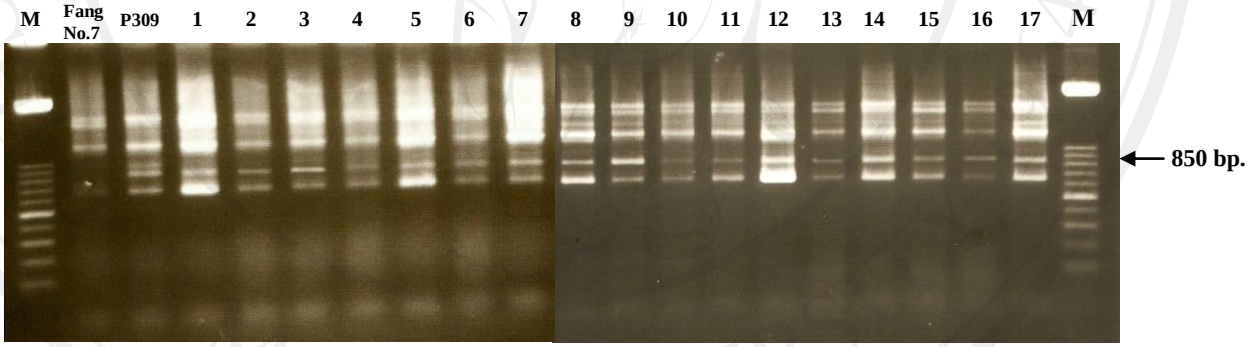


Figure 4.23 PCR profiles of cultivar Fang No.7 (female parent), line P309 (male parent), and their 17 powdery mildew resistant BC_1F_2 hybrids generated by SCAR primer ScOPD-10.

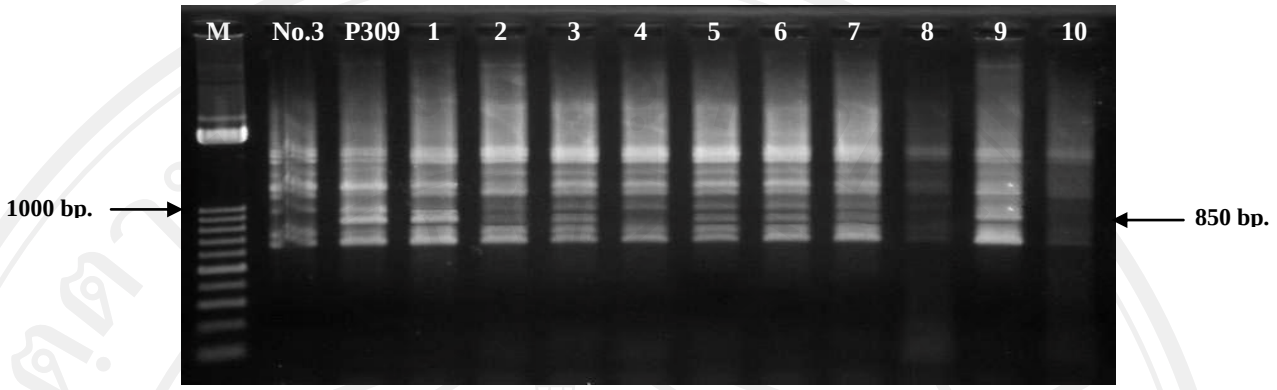


Figure 4.24 PCR profiles of line No.3 (female parent), line P309 (male parent), and their 10 powdery mildew resistant BC_2F_2 hybrids generated by SCAR primer ScOPD-10.

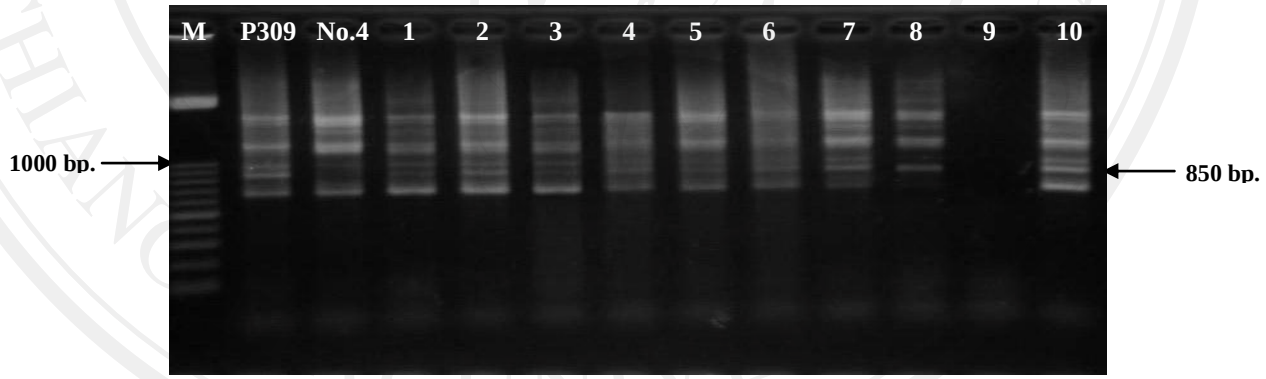


Figure 4.25 PCR profiles of line P309 (female parent), line No.4 (male parent), and their 10 powdery mildew resistant BC_2F_2 hybrids generated by SCAR primer ScOPD-10.

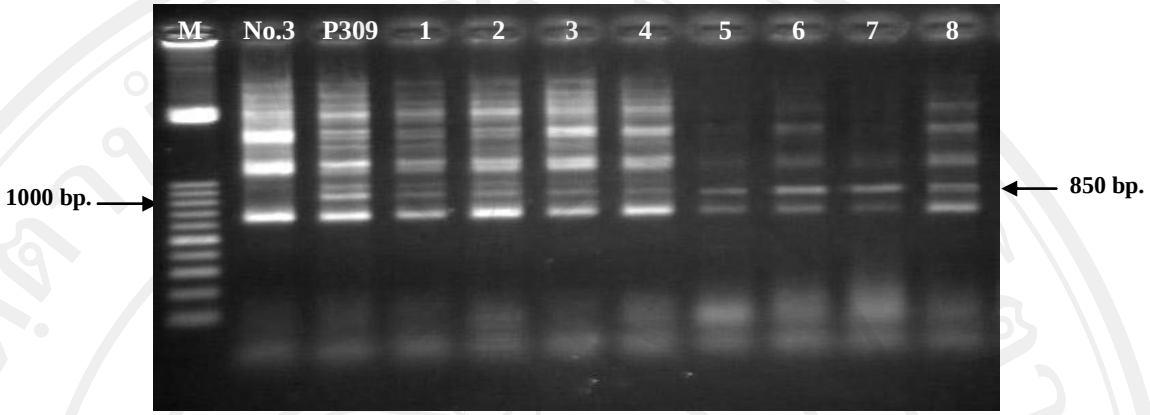


Figure 4.26 PCR profiles of line No.3 (female parent), line P309 (male parent), and their 8 powdery mildew resistant BC_3F_2 hybrids generated by SCAR primer ScOPD-10.

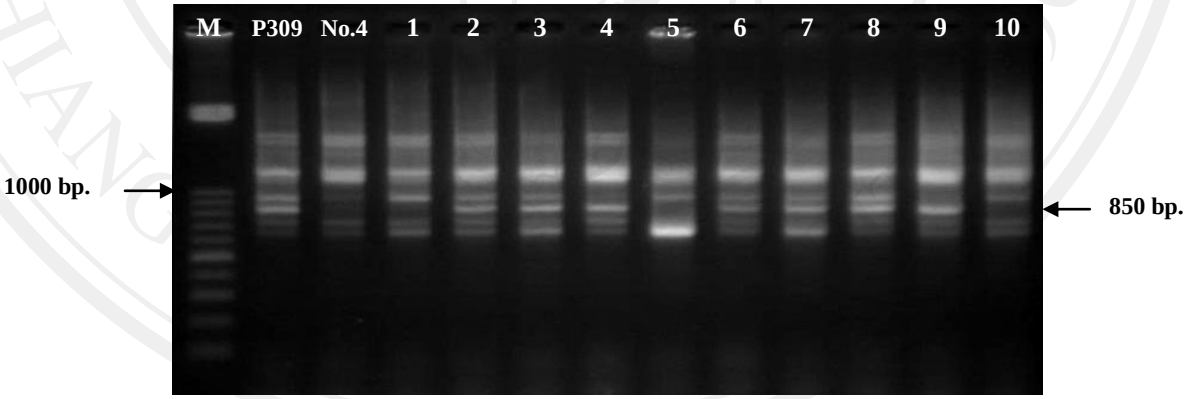


Figure 4.27 PCR profiles of line P309 (female parent), line No.4 (male parent), and their 10 powdery mildew resistant BC_3F_2 hybrids generated by SCAR primer ScOPD-10.

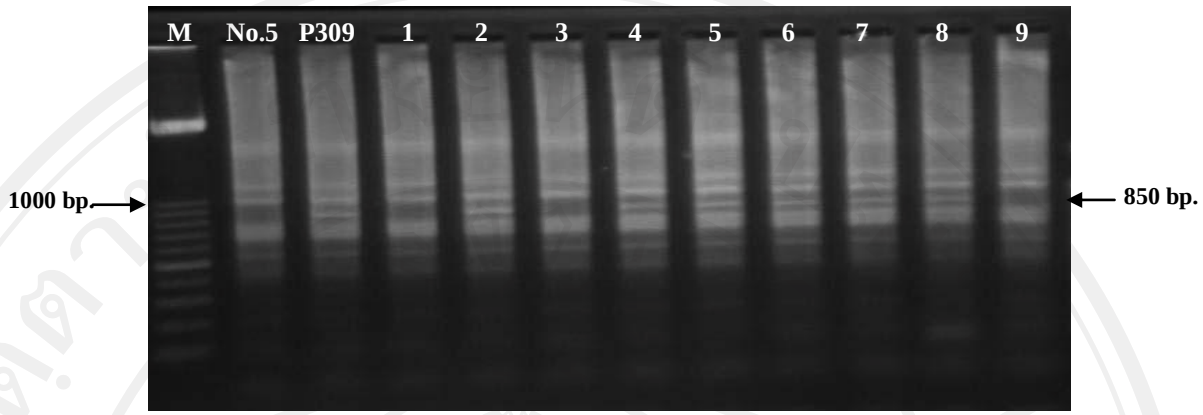


Figure 4.28 PCR profiles of line No.5 (female parent), line P309 (male parent), and their 9 powdery mildew resistant BC_3F_2 hybrids generated by SCAR primer ScOPD-10.

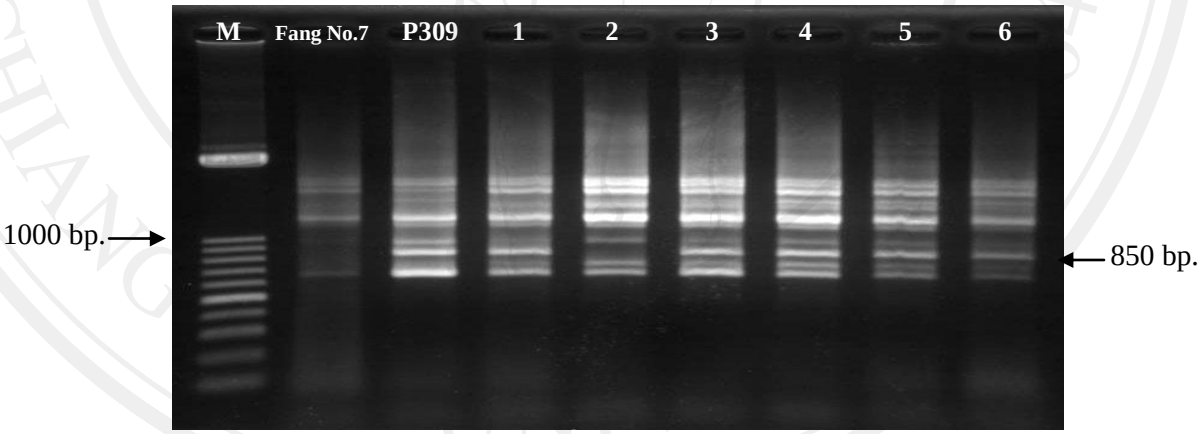


Figure 4.29 PCR profiles of cultivar Fang No.7 (female parent), line P309 (male parent), and their 6 powdery mildew resistant BC_3F_2 hybrids generated by SCAR primer ScOPD-10.

4.5 Morphological characteristics, yield and powdery mildew resistance

Comparison of morphological characteristics, yield and powdery mildew resistance of BC_3F_3 progenies of four crosses derived from No.3 × P309, P309 ×No.4, No.5 × P309 and Fang No.7 × P309, four commercial parents, lines No.3, No.4, No.5 and cultivar Fang No.7 and one resistant line, P309, were conducted under greenhouse condition at two highland production areas of the Royal Project Foundation, Khun Wang Royal Project Development Centre from May to August 2010, and Ang Khang Royal Agricultural Research Station during August to October 2011.

4.5.1 Morphological characteristics

4.5.1.1 Khun Wang Royal Project Development Centre

1) Flowering

a) The average number of days to first flowering of four BC_3F_3 progenies derived from four crosses between No.3 × P309, P309 × No.4, No.5 × P309 and Fang No.7 × P309 and their parents, lines No.3, No.4, No.5 and cultivar Fang No.7 was not significantly different in statistic and it ranged between 34.47-42.47 days (Table 4.9).

b) The blooming day could be defined as the number of days from sowing to plants blooming. The earliest blooming was found in line No.3, cultivar Fang No.7 and BC_3F_3 progenies derived from No.5 × P309 at 38.73, 38.73 and 38.80 days, respectively, while the number of blooming days of other lines and BC_3F_3 progenies was not significantly different in statistic and they ranged between 42.67-46.20 days. (Table 4.9)

c) Days to first pod setting could be defined as the number of days from sowing until to first pod setting. The earliest to pod setting lines/cultivar was found in line No.3, cultivar Fang No.7 with the same number of days at 42.27 days and BC_3F_3 progenies derived from No.5 × P309 at 42.40 days. While the other lines and BC_3F_3 progenies were not significantly in difference (Table 4.9).

Table 4.9 Number of flowering, blooming and first pod setting days of tested snow pea at Khun Wang Royal Project Development Centre during May to August 2010

Line/cultivar	Number of days		
	First flowering[1/]	First blooming[1/]	First pod setting[1/]
P309	42.47	46.20 a	52.60 a
No.3	34.73	38.73 b	42.27 b
No.4	37.33	42.80 ab	47.53 ab
No.5	42.40	46.13 a	52.80 a
Fang No.7	34.60	38.73 b	42.33 b
BC_3F_3 (N0.3 × P309)	37.20	42.67 ab	47.53 ab
BC_3F_3 (P309 × No.4)	42.40	46.07 a	52.53 a
BC_3F_3 (N0.5 × P309)	34.47	38.80 b	42.40 b
BC_3F_3 (Fang No.7 × P309)	37.13	42.67 ab	47.53 ab
$LSD_{0.05}$	NS	6.05	8.21
CV (%)	13.12	8.21	9.98

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

d) Vine height measurement was performed at harvesting stage. The result indicated that the average of the tallest vine was found in BC_3F_3 progenies derived from No.3 × P309 at 233.60 cm. Cultivar Fang No.7, lines P309, No.5, BC_3F_3

progenies derived from No.5 × P309 and BC_3F_3 progenies derived from Fang No.7× P309 had similar height whereas the shortest ones was line No.4 and BC_3F_3 progenies derived from P309 × No.4 at 108.61 and 88.91 cm, respectively (Table 4.10).

e) First flowering node could be defined as the number of stem node at which the first flower was initiated. The average of the highest level of first flowering node was found in lines P309, No.3, No.4 and BC_3F_3 progenies derived from P309 × No.4 at the 18.33, 19.67, 19.70 and 19.90 nodes, respectively. Cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 had similar height level of first flowering node. Meanwhile the lowest level of first flowering node was found in line No. 5 at the 9.63 nodes (Table 4.10).

f) Average flower number per inflorescence could be defined as the flower number occurred on each inflorescence at each node. The result indicated that the greatest average number of flower per inflorescence were BC_3F_3 progenies derived from No.3 × P309, BC_3F progenies derived from P309 × No.4, BC_3F_3 progenies derived from No.5 × P309, lines P309, No.4 and No.5 at 1.90, 1.93, 2.00, 2.00, 2.30 and 2.48 flowers, respectively. Whereas the least average number of flowers per inflorescence was found in cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 with the same number at 1.0 flower per inflorescence (Table 4.10).

g) The highest average node level of first pod setting was found in lines No.3, No.4 and BC_3F_3 progenies derived from P309 × No.4 at the 21^{st}, 20^{th} and 21^{st} nodes, respectively. Whereas the average lowest first node level of pod setting was found in line No.5 at the 11^{st} nodes (Table 4.10).

h) The greatest average number of pods per inflorescence was found in line P309 at 1.36 pods followed by BC_3F_3 progenies derived from P309 × No.4, BC_3F_3 progenies derived from No.5 × P309, lines No.4 and No.5 with the similar average number of pods at 1.07 pod per inflorescences and BC_3F_3 progenies derived from No.3 × P309 had the pod per inflorescences at 1.18 pods. Meanwhile the least average number of pods per inflorescences was line No.3, cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 with the similar average number at 1.00 pod per inflorescences (Table 4.10).

Table 4.10 The average of vines height, first flowering node, number of flower per inflorescence, first pod setting and pod per inflorescence of tested snow pea at Khun Wang Royal Project Development Centre from May to August 2010

Line/cultivar	Vine height[1/] (cm)	First flowering Node[1/]	Flower number per inflorescence[1/]	First node to pod setting[1/]	Pod per bunch[1/]
P309	205.84 b	18.33 abc	2.00 ab	18.22 bc	1.36 a
No.3	123.67 c	19.67 ab	1.50 bc	20.95 a	1.00 c
No.4	108.61 cd	19.73 ab	2.30 ab	19.88 ab	1.12 bc
No.5	199.57 b	9.63 f	2.48 a	11.26 e	1.05 bc
Fang No.7	187.53 b	16.27 d	1.00 c	16.93 c	1.00 c
BC_3F_3 (N0.3 × P309)	233.60 a	18.03 bc	1.90 ab	18.37 bc	1.18 b
BC_3F_3 (P309 × No.4)	88.91 d	19.90 a	1.93 ab	20.69 a	1.08 bc
BC_3F_3 (N0.5 × P309)	195.47 b	12.77 e	2.00 ab	13.56 d	1.07 bc
BC_3F_3 (Fang No.7 × P309)	190.47 b	17.52 cd	1.00 c	17.55 c	1.00 c
$LSD_{0.05}$	1.36	1.7	0.87	2.05	0.14
CV (%)	8.37	5.81	28.21	6.76	7.46

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

i) The node number to first branch varied due to lines and cultivar. Lines No.3, No.4, BC_3F_3 progenies derived from P309 × No.4, line No.5 and BC_3F_3 progenies derived from No.5 × P309 could branch the side shoot at the lowest average node at 1.00, 1.17, 1.60, 4.40 and 4.62 nodes, respectively. Whereas, BC_3F_3 progenies derived from Fang No.7 × P309 and BC_3F_3 progenies derived from No.3 × P309 could yield side shoot at average node number at 9.42 and 9.50, respectively. (Table 4.11)

j) The number of branches of BC_3F_3 progenies derived from No.3 × P309 was the greatest number at 8.53 branches followed by the average branches number of line P309 was 5.90 branches. The least average branches number per plant presented in cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309, were 0.07 and 0.10 branch, respectively (Table 4.11).

k) Internodes length, in this trial, average internodes length from node number 7^{th} to 16^{th} was recorded. It was indicated that BC_3F_3 progenies derived from Fang No.7 × P309, cultivars Fang No.7, BC_3F_3 progenies derived from No.5 × P309, line No.5 and BC_3F_3 progenies derived from No.3 × P309 gave the greatest average internodes length at 9.64, 9.98, 10.07, 10.15 and 10.22 cm, respectively, followed by line P309 at 7.14 cm. The least average internodes length was found in lines No.3 and No.4 with internodes length at 4.81 and 4.82 cm, respectively and they were not different in statistic with BC_3F_3 progenies derived from P309 × No.4 at 3.99 cm (Table 4.11).

l) Number of nodes per plant, the greatest number of nodes per plant were found in BC_3F_3 progenies derived from No.3 × P309, line P309 and BC_3F_3 progenies derived from No.5 × P309 at 29.63, 28.80 and 27.99 nodes, respectively followed by line No.4 at 24.93 nodes while the least nodes number per plant was

found in cultivar Fang No.7, BC_3F_3 progenies derived from P309 × No.4, BC_3F_3 progenies derived from Fang No.7 × P309, lines No.3 and No.5 at 21.00, 21.20, 21.33, 21.53 and 22.13 nodes, respectively (Table 4.11).

Table 4.11 The average number of first branch, number of branch per plant, internodes length and number of node per plant of tested snow pea at Khun Wang Royal Project Development Centre during May to August 2010

Line/cultivar	Node to first branch[1/]	Number of branch per plant [1/]	Internodes length[1/]	Number of node per plant[1/]
P309	5.94 ab	5.90 b	7.14 b	28.80 a
No.3	1.00 c	3.70 c	4.81 c	21.53 c
No.4	1.17 c	3.27 cd	4.82 c	24.93 b
No.5	4.40 bc	2.54 cd	10.15 a	22.13 c
Fang No.7	7.91 ab	0.07 e	9.98 a	21.00 c
BC_3F_3 (N0.3 × P309)	9.50 a	8.53 a	10.22 a	29.63 a
BC_3F_3 (P309 × No.4)	1.60 c	1.64 de	3.99 c	21.20 c
BC_3F_3 (N0.5 × P309)	4.62 bc	3.60 c	10.07 a	27.99 a
BC_3F_3 (Fang No.7 × P309)	9.42 a	0.10 e	9.64 a	21.33 c
$LSD_{0.05}$	3.81	1.69	1.36	1.65
CV (%)	43.50	30.01	9.98	3.92

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

2) Yield

Harvesting was performed when edible pea pod developed to mature pod stage (Figure 4.30). The size of harvested pods was measured and recorded.

a) First harvesting date

The days of harvesting was counted from the sowing date until the first harvesting date. It was indicated that the earliest harvesting was found in line No.5, cultivar Fang No.7, BC_3F_3 progenies derived from No.5 × P309, and BC_3F_3 progenies derived from Fang No.7 × P309, which had the first harvesting date at 50.00 days and they were not significantly different with BC_3F_3 progenies derived from

No.3 × P309 which had first harvesting at 55.33 days whereas lines P309, No.3 and No.4 took 65.00-67.00 days. The lateness was found in BC_3F_3 progenies derived from P309 × No.4 at 78 days (Table 4.12).

b) Number of day to harvest

Harvesting period in this trial showed that the longest harvesting duration was found in BC_3F_3 progenies derived from No.5 × P309, BC_3F_3 progenies derived from No.3 × P309, BC_3F_3 progenies derived from Fang No.7 × P309 and line P309 at 40.00, 37.67, 32.67 and 28.00 days, respectively. Then followed by the harvesting duration of line No.4, No.5 and cultivar Fang No.7 which were similar at 17.00 days. The shortest harvesting duration was found in line No.3, only 1 day (Table 4.12).

Table 4.12 First harvesting date and number of day to harvest of tested snow pea at Khun Wang Royal Project Development Centre during May to August 2010

Line/cultivar	First harvesting date (days) [1/]	No. of day to harvest (days) [1/]
P309	65.00 bc	28.00 abc
No.3	67.00 b	1.00 d
No.4	67.00 b	17.00 bcd
No.5	50.00 d	17.00 bcd
Fang No.7	50.00 d	17.00 bcd
BC_3F_3 (N0.3 × P309)	55.33 cd	37.67 a
BC_3F_3 (P309 × No.4)	78.00 a	12.33 cd
BC_3F_3 (N0.5 × P309)	50.00 d	40.00 a
BC_3F_3 (Fang No.7 × P309)	50.00 d	32.67 ab
$LSD_{0.05}$	9.74	19.02
CV (%)	9.52	48.79

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

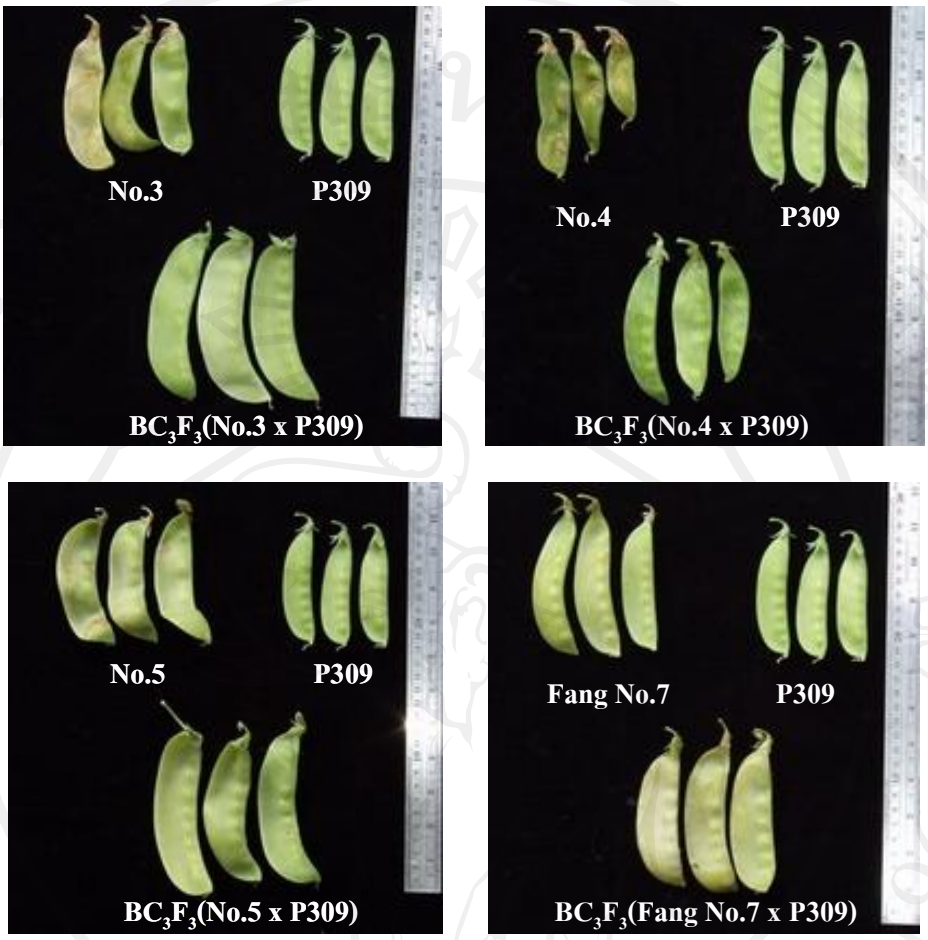


Figure 4.30 Pod characteristics of snow pea lines/cultivar and BC_3F_3 progenies at Khun Wang Royal Project Development Centre during May to August 2010

c) Pod length

Pod length of edible matured pod stage was recorded. The result showed that the longest average pod length was found in BC_3F_3 progenies derived from No.3 × P309, cultivar Fang No.7, P309, BC_3F_3 progenies derived from Fang No.7 × P309, line No.3 and BC_3F_3 progenies derived from No.5 × P309 at 8.79, 8.32, 8.11, 7.63, 7.56 and 7.53 cm, respectively. The shortest pod length was found in BC_3F_3 progenies derived from P309 × No.4 and line No.4 at 5.83 and 6.20 cm, respectively (Table 4.13).

d) Pod width

Pod width of edible matured pod stage was recorded. The result showed that the greatest average pod width was found in BC_3F_3 progenies derived from three crosses, No.5 × P309, No.3 × P309, Fang No.7 × P309, line No.5 and cultivar Fang No.7 at 2.87, 2.75, 2.62, 2.61 and 2.48 cm, respectively. The least average pod width was found in BC_3F_3 progenies derived from P309 × No.4 at 1.92 cm but it was not statistically different with lines P309 and No.4 which had the same pod width at 2.1 cm (Table 4.13).

e) Seed per pod

Number of seeds per pod of matured seeds were recorded. The result showed that the highest average seed number per pod was found in BC_3F_3 progenies derived from P309 × No.4, cultivar Fang No.7, BC_3F_3 progenies derived from Fang No.7 × P309, BC_3F_3 progenies derived from No.3 × P309 and line P309 at 5.21, 5.06, 4.41, 3.96 and 3.96 seeds, respectively. The least average seed number per pod was found in line No.4, BC_3F_3 progenies derived from No.5 × P309, lines No.5 and No.3 at 2.56, 2.87, 3.06 and 3.30 seeds, respectively (Table 4.13).

f) Pod weight

Pod weight of each line/cultivar was recorded. The result showed that the greatest average pod weight was found in BC_3F_3 progenies derived from No.3 × P309, BC_3F_3 progenies derived from Fang No.7 × P309, BC_3F_3 progenies derived from No.5 × P309, cultivar Fang No.7 and line No.5 at 8.31, 7.82, 7.47, 7.45, 6.93 grams, respectively. Meanwhile, the least average pod weight was found in lines No.4, P309, and BC_3F_3 progenies derived from P309 × No.4, at 3.63, 3.64 and 4.35 grams, respectively (Table 4.13).

Table 4.13 Pod length and width, number of seeds per pod and pod weight of tested snow pea at Khun Wang Royal Project Development Centre during May to August 2010

Line/cultivar	Pod length (cm) [1/]	Pod width (cm) [1/]	No. of seed per pod (seeds) [1/]	Pod weight (grams) [1/]
P309	8.11 ab	2.08 cde	3.96 abcd	3.64 d
No.3	7.56 abc	2.39 bcd	3.30 bcd	5.68 bc
No.4	6.20 cd	2.05 de	2.56 d	3.63 d
No.5	7.18 bcd	2.61 ab	3.06 cd	6.93 ab
Fang No.7	8.32 ab	2.48 abc	5.06 ab	7.45 ab
BC_3F_3 (N0.3 × P309)	8.79 a	2.75 ab	3.96 abcd	8.31 a
BC_3F_3 (P309 × No.4)	5.83 d	1.92 e	5.21 a	4.35 cd
BC_3F_3 (N0.5 × P309)	7.53 abc	2.87 a	2.87 cd	7.47 ab
BC_3F_3 (Fang No.7 × P309)	7.63 abc	2.62 ab	4.41 abc	7.82 a
$LSD_{0.05}$	1.60	0.42	1.80	1.79
CV (%)	12.37	10.08	27.24	16.87

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

i) Number of pod per plant

Number of pod per plant was recorded. The highest average of number of pod per plant was found in BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from No.5 × P309 at 12.63 and 10.33 pods, respectively, followed by BC_3F_3 progenies derived from Fang No.7 × P309 and line P309 at 8.74 and 8.23 pods, respectively. The least average pod number per plant was found in lines No.3 and No.4 at 1.31 and 3.56 pods, respectively (Table 4.14).

j) Total pod weight per plant

The total pod weight per plant of each line/cultivar was recorded. The result indicated that the highest average pod weight per plant were found in

BC_3F_3 progenies derived from No.3 × P309, line P309 and BC_3F_3 progenies derived from No.5 × P309, at 97.99, 82.66 and 77.23 grams, respectively. Meanwhile, the least average pod weight per plant was lines No.3, No.4 and BC_3F_3 progenies derived from P309 × No.4, at 7.57, 11.92 and 19.00 grams, respectively (Table 4.14).

Table 4.14 Number of pod and pod weight per plant of tested snow pea at Khun Wang Royal Project Development Centre during May to August 2010

Line/cultivar	Number of pod per plant (pod) [1/]	Total pod weight per plant (grams) [1/]
P309	8.74 bc	82.66 ab
No.3	1.31 g	7.57 f
No.4	3.56 fg	11.92 f
No.5	7.01 cde	45.35 cd
Fang No.7	5.64 def	39.06 de
BC_3F_3 (N0.3 × P309)	12.63 a	97.99 a
BC_3F_3 (P309 × No.4)	4.23 ef	19.00 ef
BC_3F_3 (N0.5 × P309)	10.33 ab	77.23 ab
BC_3F_3 (Fang No.7 × P309)	8.23 bcd	66.88 bc
$LSD_{0.05}$	2.89	22.75
CV (%)	24.37	26.42

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

4.5.1.2 Ang Khang Royal Agricultural Station

1) Flowering

a) The day of first flowering in this trial showed that the earliest were found in line No.5 at 19.96 days followed by BC_3F_3 progenies derived from No.5 × P309 at 25.25 days. Cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 was not statistically different in the day of first flowering at 30.81

and 31.55 days, respectively. The lateness was found in BC_3F_3 progenies derived from P309 × No.4 and line No.4 at 38.31 and 37.57 days, respectively (Table 4.15).

b) The earliest blooming was found in line No.5 at 22.84 days followed by BC_3F_3 progenies derived from No.5 × P309 at 27.25 days. The latest blooming was found in BC_3F_3 progenies derived from P309 × No.4, lines No.4 and No.3 at 40.06, 39.12 and 38.01 days, respectively (Table 4.15).

c) Days to first pod setting could be defined as the total days from sowing until to first pod setting. The earliest of pod setting cultivar was found in line No.5 at 37.75 days followed by BC_3F_3 progenies derived from No.5 × P309 at 41.50 days. The day to first pod setting of lines P309, No.3 and BC_3F_3 progenies derived from No.3 × P309 were not different and it ranged between 51.50-53.25 days. The latest cultivar to first pod setting was BC_3F_3 progenies derived from P309 × No.4 at 59.75 days (Table 4.15).

d) Vine height was measured at harvesting stage. The result indicated that the tallest average vines height were found in line P309 at 244.06 cm followed by cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 at 221.63 and 214.91 cm, respectively. While vine height of line No.5 and BC_3F_3 progenies derived from No.5 × P309 were not significantly different. The shortest vine height was found in BC_3F_3 progenies derived from P309 × No.4 at 103.43 cm (Table 4.16).

e) First flowering node could be defined as the stem node number at which the first flower was initiated. Counting first flowering node in this experiment found that the highest average level of first flowering node were lines No.4, P309, BC_3F_3 progenies derived from P309 × No.4, BC_3F_3 progenies derived from No.3 ×

P309, BC_3F_3 progenies derived from Fang No.7 × P309 and cultivar Fang No.7 at 17.84, 17.69, 17.20, 17.10, 17.10 and 16.90 nodes, respectively followed by line No.3 at 16.20 nodes. The lowest average level of first flowering node was found in line No. 5 at 10.52 nodes (Table 4.16).

Table 4.15 Number of day to first flowering, blooming and first pod setting of tested snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	Number of days		
	First flowering[1/]	First blooming[1/]	First pod setting[1/]
P309	35.69 b	35.52 bc	53.00 c
No.3	35.76 b	38.01 ab	53.25 c
No.4	37.57 a	39.12 a	56.50 b
No.5	19.96 f	22.84 f	37.75 f
Fang No.7	30.81 d	32.32 d	46.00 d
BC_3F_3 (N0.3 × P309)	33.66 c	35.33 c	51.50 c
BC_3F_3 (P309 × No.4)	38.31 a	40.06 a	59.75 a
BC_3F_3 (N0.5 × P309)	25.25 e	27.25 e	41.50 e
BC_3F_3 (Fang × P309)	31.55 d	33.78 cd	46.75 d
$LSD_{0.05}$	1.70	2.65	1.90
CV (%)	3.63	5.37	2.63

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

f) Number of flower per inflorescence could be defined as the flower number occurred on each inflorescence at each node. The result indicated that the highest average number of flower per inflorescence was found in line P309 at 1.71 flowers followed by line No.4 and BC_3F_3 progenies derived from P309 × No.4 at 1.42 and 1.39 flowers, respectively. Meanwhile the least number of flower per

inflorescence were line No.5, cultivar Fang No.7, BC_3F_3 progenies derived from Fang No.7 × P309, BC_3F_3 progenies derived from No.3 × P309 and line No.3 at, 1.00, 1.00, 1.00, 1.04 and 1.06 flowers per inflorescence, respectively (Table 4.16).

g) First pod setting; The result indicated that the highest average node level of first pod setting were line No.4, BC_3F_3 progenies derived from P309 × No.4, line P309, and BC_3F_3 progenies derived from Fang No.7 × P309 at the 18.79, 18.13, 18.04 and 17.48 nodes, respectively followed by BC_3F_3 progenies derived from No. × P309 at 17.31 nodes. The average lowest first node level of pod setting was line No.5 and BC_3F_3 progenies derived from No.5 × P309 at 10.86 and 11.81 nodes, respectively (Table 4.16).

h) The greatest number of pod per inflorescences was found in line P309 at 1.64 pods followed by line No.4 and BC_3F_3 progenies derived from P309 × No.4 at 1.16 and 1.22 pods, respectively. Meanwhile the least average pod number per inflorescences were lines No.3, No.5, cultivar Fang No.7, BC_3F_3 progenies derived from No.3 × P309, BC_3F_3 progenies derived from No.5 × P309 and BC_3F_3 progenies derived from Fang No.7 × P309 at 1.01, 1.00, 1.00, 1.04 and 1.00 pod, respectively (Table 4.16).

Table 4.16 The average of vine height, first flowering node, number of flower per inflorescences, first node to pod setting and pod per inflorescences of tested snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	Vine height (cm) [1/]	First flowering node[1/]	Number of flower per inflorescences[1/]	First node to pod setting[1/]	Number of pod per inflorescences[1/]
P309	244.06 a	17.69 a	1.71 a	18.04 ab	1.64 a
No.3	120.69 e	16.20 b	1.06 cd	16.56 c	1.01 c
No.4	118.80 e	17.84 a	1.42 b	18.79 a	1.16 b
No.5	179.04 d	10.52 d	1.00 d	10.86 d	1.00 c
Fang No.7	221.63 b	16.90 ab	1.00 d	16.73 c	1.00 c
BC_3F_3 (N0.3 × P309)	201.03 c	17.10 ab	1.12 c	17.31 bc	1.06 c
BC_3F_3 (P309 × No.4)	103.43 f	17.20 ab	1.39 b	18.13 ab	1.22 b
BC_3F_3 (N0.5 × P309)	185.85 d	12.00 c	1.04 cd	11.81 d	1.04 c
BC_3F_3 (Fang No.7 × P309)	214.91 bc	17.10 ab	1.00 d	17.48 abc	1.00 c
$LSD_{0.05}$	14.64	1.07	0.11	1.31	0.11
CV (%)	5.68	4.64	6.57	5.54	6.4

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

i) The number of node to first branch varied due to lines and cultivar. Lines No.3, BC_3F_3 progenies derived from No.5 × P309, BC_3F_3 progenies derived from P309 × No.4, lines No.5 and No.4 could branch the side shoot at the lowest node at 1.37, 1.56, 1.91, 2.73 and 2.89 nodes, respectively. Meanwhile the highest average node level to first branch was found in cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 at the 10.99 and 11.91 nodes, respectively (Table 4.17).

j) The number of branches per plant of cultivar Fang No.7 was the greatest at 4.74 branches followed by BC_3F_3 progenies derived from Fang No.7 × P309 at 3.99 branches. The least average number of branches per plant was found in line P309, BC_3F_3 progenies derived from P309 × No.4, lines No.5, No.4 and BC_3F_3 progenies derived from No.5 × P309 at 1.31, 1.87, 1.90, 2.02 and 2.02 branches, respectively (Table 4.17).

k) Internodes length from the node number 7^{th} to 16^{th} nodes was recorded. It was indicated that BC_3F_3 progenies derived from Fang No.7 × P309 had the greatest average internodes length at 8.63 cm followed by cultivar Fang No.7 at 7.38 cm. Meanwhile the least internode length was BC_3F_3 progenies derived from P309 × No.4 at 2.42 cm (Table 4.17).

Table 4.17 Number of node to first branch, number of branch per plant and internode length of tested snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	Node to first branch[1/]	No. of branch per plant[1/]	Internodes length[1/]
P309	4.42 c	1.31 e	4.80 e
No.3	1.37 d	3.12 c	3.65 f
No.4	2.89 cd	2.02 de	3.11 f
No.5	2.73 cd	1.90 de	6.61 c
Fang No.7	10.99 a	4.74 a	7.38 b
BC_3F_3 (N0.3 × P309)	8.00 b	2.45 cd	6.47 cd
BC_3F_3 (P309 × No.4)	1.91 d	1.87 de	2.42 g
BC_3F_3 (N0.5 × P309)	1.56 d	2.02 de	5.99 d
BC_3F_3 (Fang No.7 × P309)	11.91 a	3.99 b	8.63 a
$LSD_{0.05}$	2.31	0.73	0.61
CV (%)	31.07	19.17	7.63

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

2) Yields

Harvesting was performed when edible pea pod developed to matured pod stage (Figure 4.31). Pod size of harvested pods was recorded.

a) First harvesting date

The days of harvesting was counted from sowing date until the first harvest date. It was indicated that the earliest harvesting cultivar was line No.5 at 50.50 days followed by cultivar Fang No.7, BC_3F_3 progenies derived from No.5 × P309 and BC_3F_3 progenies derived from Fang No.7 × P309 which were not significantly different in statistic and they ranged between 55.00-56.0 days. Meanwhile the lateness was found in BC_3F_3 progenies derived from P309 × No.4 at 72.25 days (Table 4.18).

b) Number of day to harvest

Harvesting period in this trial showed that the longest harvesting duration found in BC_3F_3 progenies derived from Fang No.7, line No.5, BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from No.5 × P309 at 38.50, 38.50, 33.25 and 33.00 days, respectively followed by the harvesting duration of lines P309, No.3 and No.4 at 32.00, 31.00 and 31.00 days, respectively. Meanwhile the shortest harvesting duration was BC_3F_3 progenies derived from P309 × No.4 at 24.75 days (Table 4.18).

Table 4.18 First harvesting date and number of day to harvest of snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	First harvesting date[1/] (days)	No. of day to harvest[1/] (days)
P309	65.00 b	32.00 bcd
No.3	64.50 b	31.00 cd
No.4	66.00 b	31.00 cd
No.5	50.50 e	38.50 ab
Fang No.7	55.00 d	38.50 ab
BC_3F_3 (N0.3 × P309)	60.00 c	33.25 abc
BC_3F_3 (P309 × No.4)	72.25 a	24.75 d
BC_3F_3 (N0.5 × P309)	56.00 a	33.00 abc
BC_3F_3 (Fang No.7 × P309)	55.00 d	39.50 a
$LSD_{0.05}$	3.41	7.38
CV (%)	3.86	15.10

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

c) Pod length

Pod length of edible matured pod stage was recorded. The result showed the longest average pod length was found in line No.4, cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 at 9.69, 9.57 and 9.09 cm, respectively. Then followed by the pod length of lines No.3, No.5, BC_3F_3 progenies derived from No.3 × P309 with ranged between 8.22-8.42 cm. Meanwhile, the shortest pod length was found in BC_3F_3 progenies derived from No.5 × P309, line P309 and BC_3F_3 progenies derived from P309 × No.4 at 7.48, 7.81 and 8.17 cm, respectively (Table 4.19).

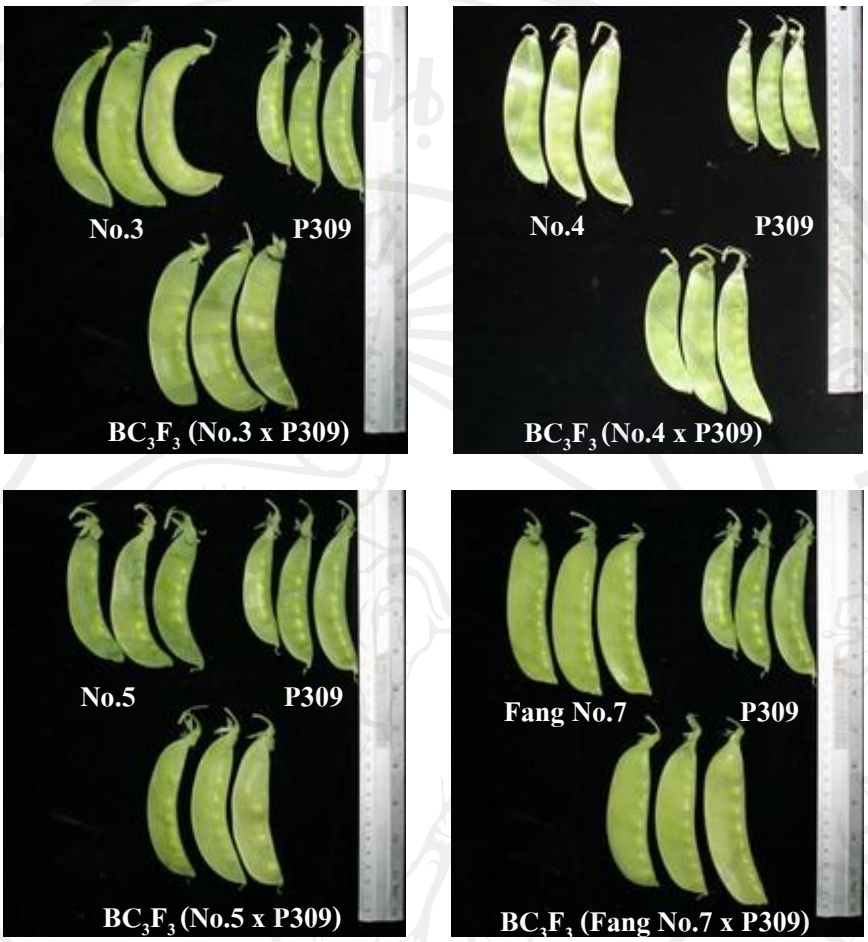


Figure 4.31 Pods characteristics of snow pea lines/cultivar at Ang Khang Royal Agricultural Station during August to October 2010.

d) Pod width

Pod width of edible matured pod stage was recorded. The result showed that the greatest average pod width was found in lines No.4, No.5, cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 at 9.69, 9.57 and 9.09 cm, respectively. Meanwhile, the shortest average pod width was cultivar P309 and BC_3F_3 progenies derived from P309 × No.4 at 1.96 and 2.06 cm, respectively (Table 4.19).

g) Seed per pod

Number of seeds per pod of matured seeds were recorded. The result showed that the greatest average number of seeds per pod was cultivar Fang No.7 and BC_3F_3 progenies derived from Fang No.7 × P309 at 5.79 and 5.34 seeds, respectively, then followed by the line No.4, BC_3F_3 progenies derived from No.5 × P309 and BC_3F_3 progenies derived from No.3 × P309 at 4.13, 3.75 and 3.80 seeds per pod. Whereas the least number of seeds per pod was lines P309, No.5, No.3 and BC_3F_3 progenies derived from P309 × No.4 at 3.18, 3.35, 3.40 and 3.44 seeds, respectively (Table 4.19).

h) Pod weight

Pod weight of each line/cultivar was recorded. The result showed that the greatest average weight per pod was found in lines No.3, No.4, BC_3F_3 progenies derived from Fang No.7 × P309, cultivar Fang No.7 and BC_3F_3 progenies derived from No.3 × P309 at 9.92, 9.26, 9.11, 8.93 and 7.61 grams, respectively. Meanwhile, the least average pod weight was found in line P309 at 3.44 grams (Table 4.19).

i) Number of pod per plant

The highest number of pod per plant was found in cultivar Fang No.7 at 23.97 pods followed by line No.5, BC_3F_3 progenies derived from No.5 × P309, line No.4 and BC_3F_3 progenies derived from No.3 × P309 at 16.69, 14.81, 14.58 and 14.31 pods, respectively. Meanwhile the least number of pod per plant was found in BC_3F_3 progenies derived from P309 × No.4 and line No.3 at 8.56 and 11.48 pods, respectively (Table 4.20).

Table 4.19 Pod length and width, number of seeds per pod and pod weight of tested snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	Pod length [1/] (cm)	Pod width [1/] (cm)	Number of seed per pod[1/] (seeds)	Pod weight[1/] (grams)
P309	7.81 cd	1.96 d	3.18 c	3.44 d
No.3	8.42 bc	2.47 c	3.40 c	9.92 a
No.4	9.69 a	2.58 abc	4.13 b	9.26 ab
No.5	8.25 c	2.65 abc	3.35 c	6.81 bc
Fang No.7	9.57 a	2.90 a	5.79 a	8.93 abc
BC_3F_3 (N0.3 × P309)	8.22 c	2.52 bc	3.75 bc	7.61 abc
BC_3F_3 (P309 × No.4)	8.17 cd	2.06 d	3.44 c	6.49 c
BC_3F_3 (N0.5 × P309)	7.48 d	2.48 c	3.80 bc	6.55 c
BC_3F_3 (Fang No.7 × P309)	9.09 ab	2.84 ab	5.34 a	9.11 ab
$LSD_{0.05}$	0.74	0.35	0.63	2.45
CV (%)	5.92	9.5	10.74	22.19

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

j) Total pod weight per plant

The total pod weight per plant of each cultivar was recorded. The result indicated that the highest average pod weight per plant was found in 7 lines/ cultivar between 98.56-124.44 grams. Whereas the least average pod weight per plant was BC_3F_3 progenies derived from P309 × No.4 and line P309 at 53.52 and 78.00 pods, respectively (Table 4.20).

Table 4.20 Number of pod, total pod weight per plant of tested snow pea at Ang Khang Royal Agricultural Station during August to October 2010

Line/cultivar	Number of pod per plant[1/] (pod)	Total pod weight per plant[1/] (grams)
P309	12.99 c	78.00 bc
No.3	11.48 cd	107.81 ab
No.4	14.58 bc	101.27 ab
No.5	16.69 b	116.38 ab
Fang No.7	23.97 a	124.44 a
BC_3F_3 (N0.3 × P309)	14.31 bc	98.56 ab
BC_3F_3 (P309 × No.4)	8.56 d	53.52 c
BC_3F_3 (N0.5 × P309)	14.81 bc	98.84 ab
BC_3F_3 (Fang No.7 × P309)	13.01 c	109.87 ab
$LSD_{0.05}$	3.48	41.02
CV (%)	16.44	28.46

[1/]Means in the same column with different letters differ statistically at the 5% level using LSD test.

4.5.2 Powdery mildew resistance evaluation

Experiments on powdery mildew resistance were conducted in the greenhouse at two different locations belonging to the Royal Project Foundation, Khun Wang Royal Project Development Centre and Ang Khang Royal Agricultural Station. Due to the infection of powdery mildew spread up from the lower to the upper leaves and disease infection clearly occurred from the beginning of growth to flowering stage, the evaluation was done after naturally infected and symptom occurrence one and two week on leaf of nodes at the 7^{th} nodes and 10^{th} nodes, respectively. The results are as follows;

4.5.2.1 Khun Wang Royal Project Development Center

The results showed the incidence and severity of the white spore and mycelium of powdery mildew occurred on the leaves at 35 days after transplanting. One week after infection, the disease severity on the leaf surface at the 7th node of cultivar Fang No.7 was significantly greater than others at 78.9% followed by lines No.3, No.4 and No.5 at 54.5, 54.0 and 52.8%, respectively. The least infection percentage was found in line P309, BC_3F_3 progenies derived from No.5 × P309, BC_3F_3 progenies derived from Fang No.7 × P309 were 0.8, 1.2 and 2.2%, respectively but they did not differ from BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from P309 × No.4 which had similar infection percentage at 3.7% (Figure 4.32A).

Two weeks after infection, the infection severity increased, especially in lines No.3, No.4, No.5 and cultivar Fang No.7. The incidence of leaf infection on the 10th nodes of lines No.3, No.4, No.5 and cultivar Fang No.7 was 99.3, 99.4, 99.2 and 100%, respectively. While BC_3F_3 progenies derived from P309 × No.4 and BC_3F_3 progenies derived from No.3 × P309 had the infection percentage at 20.7 and 11.7%. The least percentage of infection was found in line P309, BC_3F_3 progenies derived from Fang No.7 × P309 and BC_3F_3 progenies derived from No.5 × P309 at 1.7, 4.3 and 4.7 %, respectively (Figure 4.32B). However, the result was not significantly different from BC_3F_3 progenies derived from No.3 × P309.

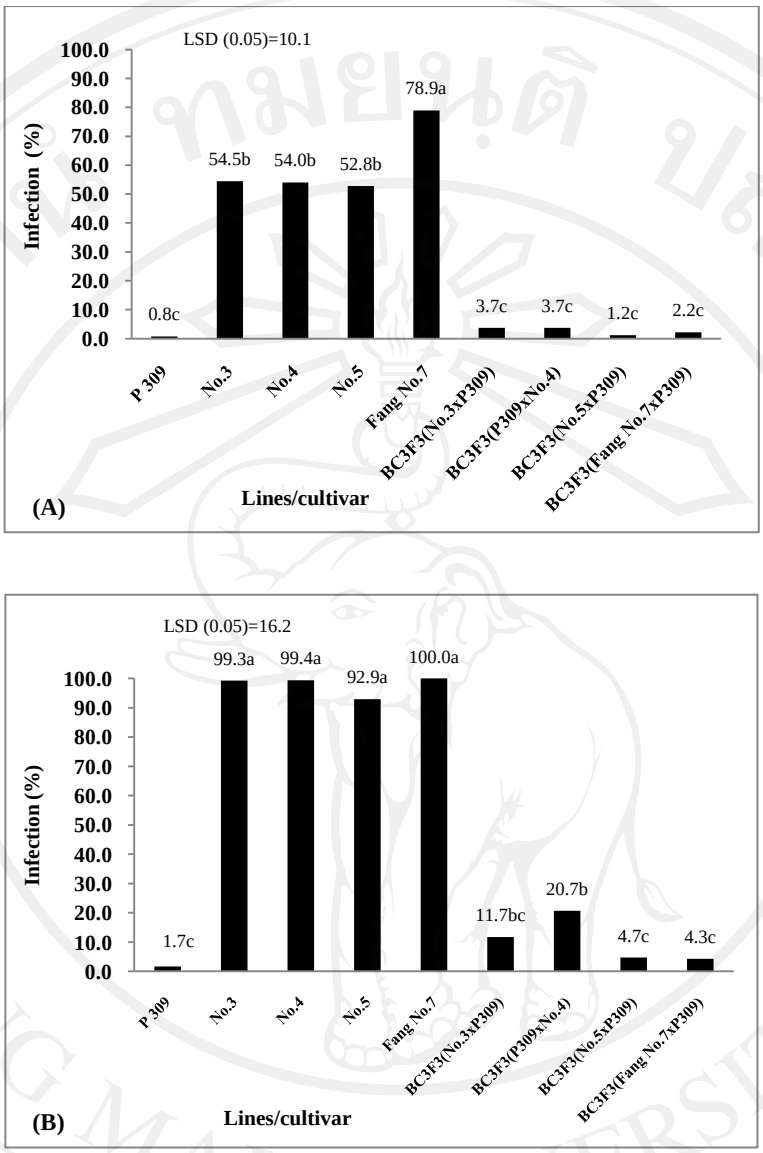


Figure 4.32 Powdery mildew infection percentage on leaf surface area at the node positions in snow pea lines/cultivar which was conducted in the greenhouse condition at Khun Wang Royal Project Development Centre during May to August 2010

A) At the 7th leaf node

B) At the 11th leaf node.

4.5.2.2 Ang Khang Royal Agricultural Station

The results of powdery mildew disease evaluation showed the incidence and severity of the white spore and mycelium of powdery mildew occurred on the leaf at 35 days after transplanting. The greatest infection severity was found in BC_3F_3 progenies derived from No.5 × P309 at 3.0%. Whereas the least average percentage of infection was found in line No.3, No.4, No.5 and BC_3F_3 progenies derived from Fang No.7 × P309, at 0.5, 0.1, 0.6 and 0.3 %, respectively (Figure 4.33A).

The snow pea leaves of all lines/cultivar on the 10^{th} were severely infected. The result showed that line P309, No.3, BC_3F_3 progenies derived from P309 × No.4 and BC_3F_3 progenies derived from Fang No.7 × P309 had greater infection severity than line No.4 (Figure 4.33B).

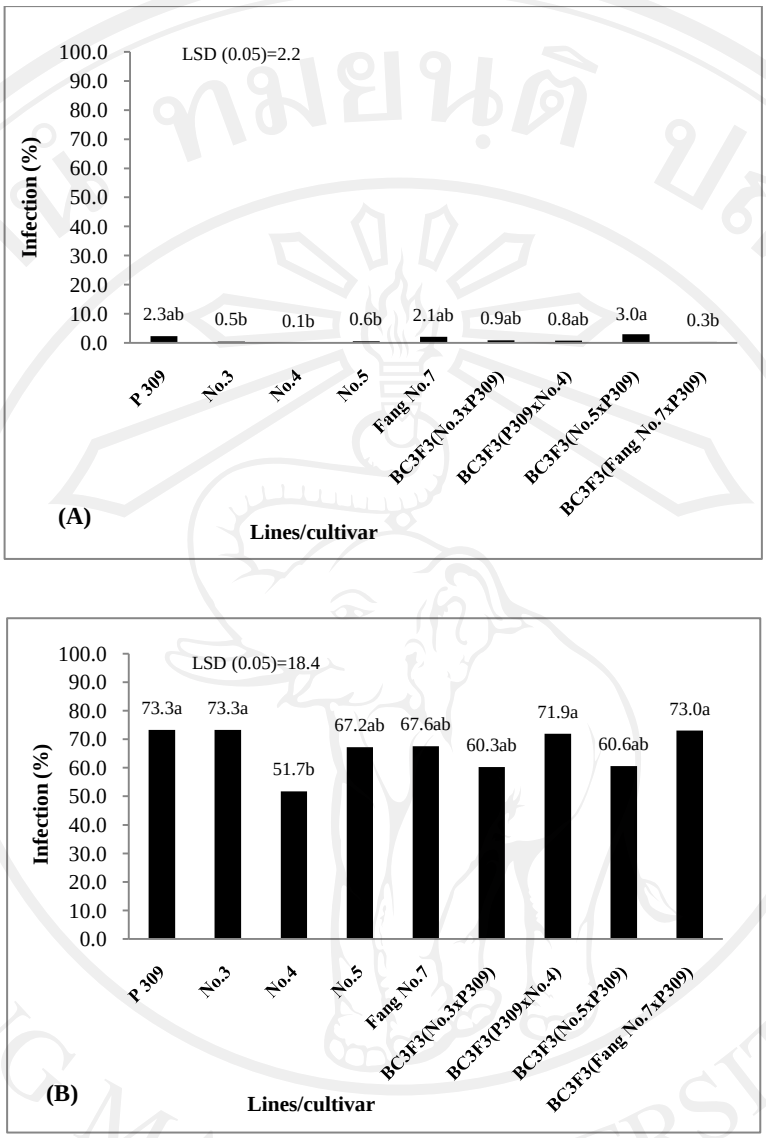


Figure 4.33 Powdery mildew infection percentage on leaf surface area at various node positions in snow pea lines/cultivar which was conducted in the field condition at Ang Khang Royal Agricultural Station during August to October 2010

A) At the 7th leaf node

B) At the 11th leaf node.

4.6 Customer preference trial

Snow pea pods of BC_3F_3 progenies derived from No.3 × P309, P309 × No.4, No.5 × P309, Fang No.7 × P309 and lines No.3. No.4, No.5 and cultivar Fang No.7 were tested at two locations, Khun Wang Royal Project Development Center and Ang Khang Royal Agricultural Station in order to evaluate the preference or perception of consumers. The trial was conducted to test for 6 characters, pod size, pod shape, crispness, sweetness, colors and scent. The results were as follows;

4.6.1 Khun Wang Royal Project Development Centre

Matured fresh pod of lines P309, No.5, cultivar Fang No.7, BC_3F_3 progenies derived from No.3 × P309, BC_3F_3 progenies derived from No.5 × P309 and BC_3F_3 progenies derived from Fang No.7 × P309, were tested whereas pods of 3 lines, No.3, No.4 and BC_3F_3 progenies derived from P309 × No.4 could not be harvested because they were still immature. The result of each character which was accepted by the tested consumers was as follows;

4.6.1.1 Pod size; The highest average acceptance scores on pod size was found in line P309, BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from No.5 × P309 at 3.34, 3.28 and 3.14, respectively. While line No.5 and BC_3F_3 progenies derived from Fang No.7 × P309 were similarly accepted. The least average acceptance score was found in cultivar Fang No.7 at 1.97 (Table 4.21, Figure 34A).

4.6.1.2 Pod shape of line P309 and BC_3F_3 progenies derived from No.3 × P309 had the highest acceptance score at 3.55 and 3.28, respectively followed by

BC_3F_3 progenies derived from No.5 × P309 at 3.03. The least average acceptance score was cultivar Fang No.7 at 2.00 (Table 4.21, Figure 34A).

4.6.1.3 Pod crispness; The tested consumers gave the highest average acceptance score of pod crispness on BC_3F_3 progenies derived from No.5 × P309, BC_3F_3 progenies derived from Fang No.7 × P309 and line No.5 at 3.34, 3.26 and 3.14, respectively followed by line P309 and cultivar Fang No.7 with the similar scores. The least average score was found in BC_3F_3 progenies derived from No.3 × P309 at 2.14 (Table 4.21, Figure 34A).

4.6.1.4 Sweetness of all tested snow peas was quite favorable to the tested consumers and they were not statistically different. Their scores ranged between 2.55 to 3.10 but only BC_3F_3 progenies derived from Fang No.7 × P309 had the acceptance scores more than 3.00 (Table 4.21, Figure 34A).

4.6.1.5 Pod color of line P309, BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from No.5 × P309 were quite favorable to the tested consumers. The average acceptance score was 3.52, 3.31 and 3.17, respectively. Then followed by line No.5 and progenies BC_3F_3 derived from Fang No.7 × P309. The tested consumers were quite disliked to slightly disliked the color of cultivar Fang No.7. The average of acceptance scores was only 1.62 (Table 4.21, Figure 34A).

4.6.1.6 Scent; The tested consumer accepted on scent of all tested snow pea. The highest acceptance scores was found in BC_3F_3 progenies derived from Fang No.7 × P309 but it was not different with lines P309, No.5, BC_3F_3 progenies derived from No.3 × P309 and BC_3F_3 progenies derived from No.5 × P309. The least acceptance score was cultivar Fang No.7 at 2.38 (Table 4.21, Figure 34A).

4.6.2 Ang Khang Royal Agricultural Station

Pods of five parent lines/cultivar, a resistant line P309, and four susceptible lines/cultivar, No.3, No.4, No.5 and Fang No.7 and BC_3F_3 progenies derived from No.3 × P309, BC_3F_3 progenies derived from P309 × No.4, BC_3F_3 progenies derived from No.5 × P309 and BC_3F_3 progenies derived from Fang No.7 × P309, were tested for consumer response of each character. The results were shown as follows;

4.6.1.1 Pod size; Overall, pods of all snow pea lines/cultivar were quite favorable to the tested consumers. The average response score from the tested consumers was ranged from 2.97-3.5(Table 4.22, Figure 34B).

4.6.1.2 Pod shape of eight lines/cultivar and backcross hybrids were quite favorable to the tested consumers. The average acceptance scores ranged from 2.71-3.43. While the least acceptance score was line No.3 at 2.64 (Table 4.22, Figure 34B).

4.6.1.3 Pod crispness of all tested snow pea lines/cultivar and backcross hybrids were similarly favorable to the tested consumers. The acceptance score ranged from 3.00 - 3.64 (Table 4.22, Figure 34B).

4.6.1.4 Sweetness; the tested consumers gave the similar acceptance score to all tested snow pea lines/cultivar and backcross hybrids. The average was ranged from 2.64-3.21(Table 4.22, Figure 34B).

4.6.1.5 Pod color of line P309 and No.4 was the highest average acceptance scores at 3.93 and 3.64, respectively. While the least average acceptance score was found in BC_3F_3 progenies derived from Fang No.7 × P309, cultivar Fang No.7 and BC_3F_3 progenies derived from No.5 × P309 at 1.79, 2.07 and 2.21, respectively (Table 4.22, Figure 34B).

4.6.1.6 Scent of eight lines/cultivar and backcross hybrids were similarly favorable to the tested consumer. The average acceptance score ranged from 2.37-2.86. While the least average acceptance score was BC_3F_3 progenies derived from Fang No.7 × P309 at 2.14 (Table 4.22, Figure 34B).

Table 4.21 Consumer preference to characteristics of tested snow pea lines/cultivar from Khun Wang Royal Project Development Centre

Line/cultivar	pod size[1/]	shape[1/]	crispness[1/]	sweetness[1/]	color[1/]	scent[1/]
P309	3.34 a	3.55 a	2.72 b	2.79	3.52 a	2.86 ab
No.5	2.66 b	2.48 c	3.14 ab	2.76	2.48 b	2.72 ab
Fang No.7	1.97 c	2.00 d	2.72 b	2.59	1.62 c	2.38 b
BC_3F_3(No.3 × P309)	3.28 a	3.28 ab	2.14 c	2.55	3.31 a	2.86 ab
BC_3F_3(No.5 × P309)	3.14 ab	3.04 b	3.34 a	2.90	3.17 a	2.79 ab
BC_3F_3(Fang No.7 × P309)	2.72 b	2.52 c	3.26 ab	3.10	2.52 b	2.97 a
$LSD_{0.05}$	0.54	0.47	0.56	NS	0.45	0.54
CV (%)	36.22	32.30	37.63	40.54	31.62	37.57

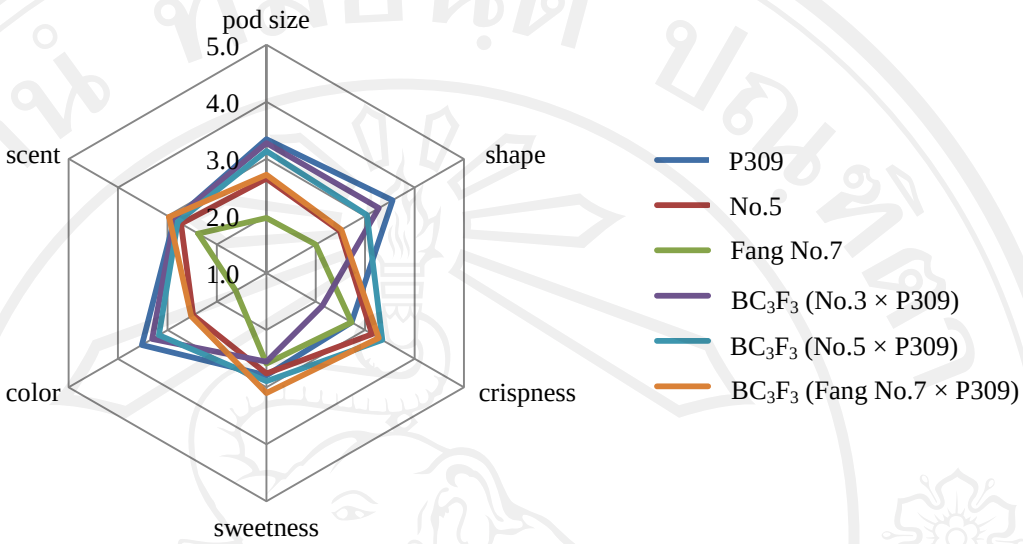
[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

Table 4.22 Consumer preference to characteristics of tested snow pea lines/cultivar from Ang Khang Royal Agricultural Station

Line/cultivar	pod size[1/]	shape[1/]	crispness[1/]	sweetness[1/]	color[1/]	scent[1/]
P309	3.50	3.43 a	3.50	2.71	3.93 a	2.36 ab
No.3	2.86	2.64 b	3.36	3.21	2.64 cde	2.86 a
No.4	2.79	2.76 ab	3.43	2.64	3.64 ab	2.64 ab
No.5	3.00	2.71 ab	3.14	2.79	2.64 cde	2.57 ab
Fang No.7	3.21	3.00 ab	3.57	3.21	2.07 ef	2.57 ab
BC_3F_3 (No.3 × P309)	2.79	2.71 ab	3.64	2.71	2.86 cd	2.71 ab
BC_3F_3 (P309 × No.4)	3.21	3.29 ab	3.29	2.79	3.21 bc	2.57 ab
BC_3F_3 (No.5 × P309)	2.93	3.00 ab	3.29	3.07	2.21 def	2.64 ab
BC_3F_3 (Fang No.7 × P309)	3.14	3.14 ab	3.00	2.93	1.79 f	2.14 b
$LSD_{0.05}$	NS	0.78	NS	NS	0.69	0.71
CV (%)	35.54	35.14	25.86	34.99	33.00	37.17

[1/] Means in the same column with different letters differ statistically at the 5% level using LSD test.

(A)



(B)

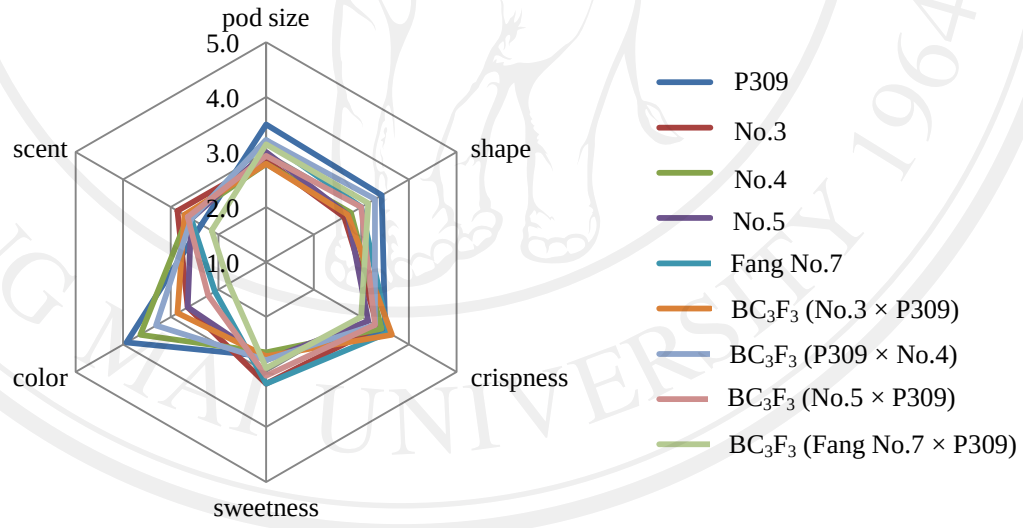


Figure 4.34 The weight different among the mean of each trait on polar plot for the sensory comparison profile of;

A) Progenies derived from 3rd backcross generation and three parent cultivars which were harvested from Khun Wang Royal Project Development Centre

B) Progenies derived from 3rd backcross generation and five parent cultivars which were harvested from Ang Khang Royal Agricultural Station