BIBLIOGRAPHY

ALIÑO, WINNIE V. APRIL 2012. Evaluation of Disease Resistance on Varieties of Different Organically Grown Vegetables. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted to evaluate the disease resistance of varieties of different organically grown vegetables.

New varieties of vegetables like tomato, Chinese cabbage and garden pea were evaluated at different agro ecological zones.

Fungal pathogens found related to these crops, leaf spot (*Alternaria brassicae*), white rust *(Albugo candida*) and powdery mildew (*Erysiphe sp.)* in Chinese cabbage, powdery mildew *(Erysiphe polygoni*) in garden pea and late blight (*Phytophthora infestans)* in tomato.

Results revealed that Summer Star and Baguio Star varieties of Chinese cabbage, TM 26, TM 42 and TM 43 in tomatoes, CGP 13 and Betag varieties in garden pea were resistant to major fungal diseases affecting these crops.

RESULTS AND DISCUSSION

Meteorological Data

The weather during the entire duration of the experiment is shown in Table 1. Apparently, the environmental conditions during the conduct of the study favored the development of many diseases. The minimum temperature ranged from 13.5 to 21.7% while the maximum temperature ranged from 21.8 to 27.9%. On the other hand, the relative humidity was also within the range that favors late blight development and other disease (86 to 102.5%). The oomycetes grows and sporulates most abundantly at a relative humidity near 100% and at temperatures between 15 and 25% (Agrios, 2005).

Table 1. Mean air temperature (^{0}C), relative humidity (%) and rainfall

MONTHS	TEMPERATURE (%)		RELATIVE HUMIDITY(%)	RAINFALL
	MAXIMUM	MINIMUM		
OCTOBER	26.5	17.6	98	11.2
NOVEMBER	23.3	15.6	87	2.2
DECEMBER	23.1	14.5	87	0.6
JANUARY	27.9	21.7	102.5	1.4
FEBRUARY	21.8	13.5	86	-

Diseases of Chinese cabbage (*Brassica oleracea L.*)

Leaf Spot disease (*Alternaria brassicae*)

Table 2 shows the mean percentage leaf spot disease of Chinese cabbage in Cattubo, Tulodan, Atok (2,230 masl), Nan-agto, Natubleng, Buguias (2,280 masl) and BSU Balili, La Trinidad (1,332 masl). Results revealed that the lowest leaf spot infection was recorded in the variety Baguio Star planted in the higher elevation (Tulodan and Natubleng) but had a higher infection at low elevation (La Trinidad). Results further showed that the leaf spot infection as shown in Figure 1 (a) and (b) was found at Tulodan, Atok and Balili, La Trinidad. Difference among treatments however was not significant.

Table 2. Mean percentage of leaf spot infection on different varieties of Chinese cabbage

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (Mid elevation) 2,230 masl	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	45.00	47.50	17.50
Baguio star	35.00	3.00	4.00
Dou Kang 4	17.50	57.50	12.50
Summer star	42.50	27.50	6.50
Green cool (ck)	62.50	35.00	1.00
CV	13.24%	34.09%	28.73%

Among the varieties evaluated, Baguio Star exhibited moderate susceptibility to (51-75%) leaf spot at lower elevation (Trinidad, 1,332 masl) but resistant reaction at higher

elevation (Tuludan, 2,230 masl) and Natubleng (2,280 masl) with (1-25% infection). The check variety Green Cool was very susceptible to leaf spot at lower elevation (Trinidad) and moderately resistant and resistant in higher elevation (Natubleng). Except for Zao Xin Bai and Dou Kang 4, all varieties were resistant (1-25% infection) to leaf spot disease in Chinese cabbage planted at Tulodan, Atok (high elevation). Table 3 shows the reaction of different varieties of Chinese cabbage in leaf spot disease.

Table 3. Resistant reaction different Chinese cabbage to leaf spot disease infection

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	Moderately susceptible	Moderately susceptible	Resistance
Baguio star	Moderately susceptible	Resistance	Resistance
Dou Kang 4	Resistance	Moderately susceptible	Resistance
Summer star	Moderately susceptible	Moderately resistance	Resistance
Green cool (ck)	Very susceptible	Moderately resistance	Resistance

Figure 1a. Leaf spot disease occurred in Tulodan, Atok.

Figure 1b. Leaf spot disease occurred in Balili, La Trinidad.

Leaf spot disease found at three agro ecological zones was caused by *Alternaria brassicae*.

White Rust (*Albugo candida*)

Aside from leaf spot disease, white rust also occurred in three agro ecological zones. Table 4 shows the mean percentage infection of white rust infection planted in three agro ecological zones. Figure 2a shows the symptom exhibited in the leaves and Figure 2b shows the structures of white rust under the microscope. No infection of white rust was recorded in Natubleng, Buguias while minimal infection was recorded in Balili and Tulodan, However, among the different varieties, highest infection of 22.50% was recorded in variety Summer Star in Balili and 25% in Dou Kang 4 variety planted in

Table 4. Mean percentage infection of white rust disease in Chinese cabbage

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	1.50	12.50	0.00
Baguio star	3.00	2.00	0.00
Dou Kang 4	3.50	25.00	0.00
Summer star	22.50	1.50	0.00
Green cool	7.50	3.50	0.00
CV	40.56%	38.51%	0

Tulodan Atok. Difference among treatments however was not significant. In Natubleng, all varieties were highly resistant to white rust because no entry was infected with white rust while Zao Xin Bai, Baguio Star had similar reactions as the check variety Green Cool (resistant = 1 – 20%).

Table 5.Disease reaction of new varieties of Chinese cabbage in white rust disease

VARIETIES	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	Resistant	Resistant	Highly Resistant
Baguio star	Resistant	Resistant	Highly Resistant
Dou Kang 4	Resistant	Moderately Resistant	Highly Resistant
Summer star	Moderately Resistant	Resistant	Highly Resistant
Green cool (ck)	Resistant	Resistant	Highly Resistant

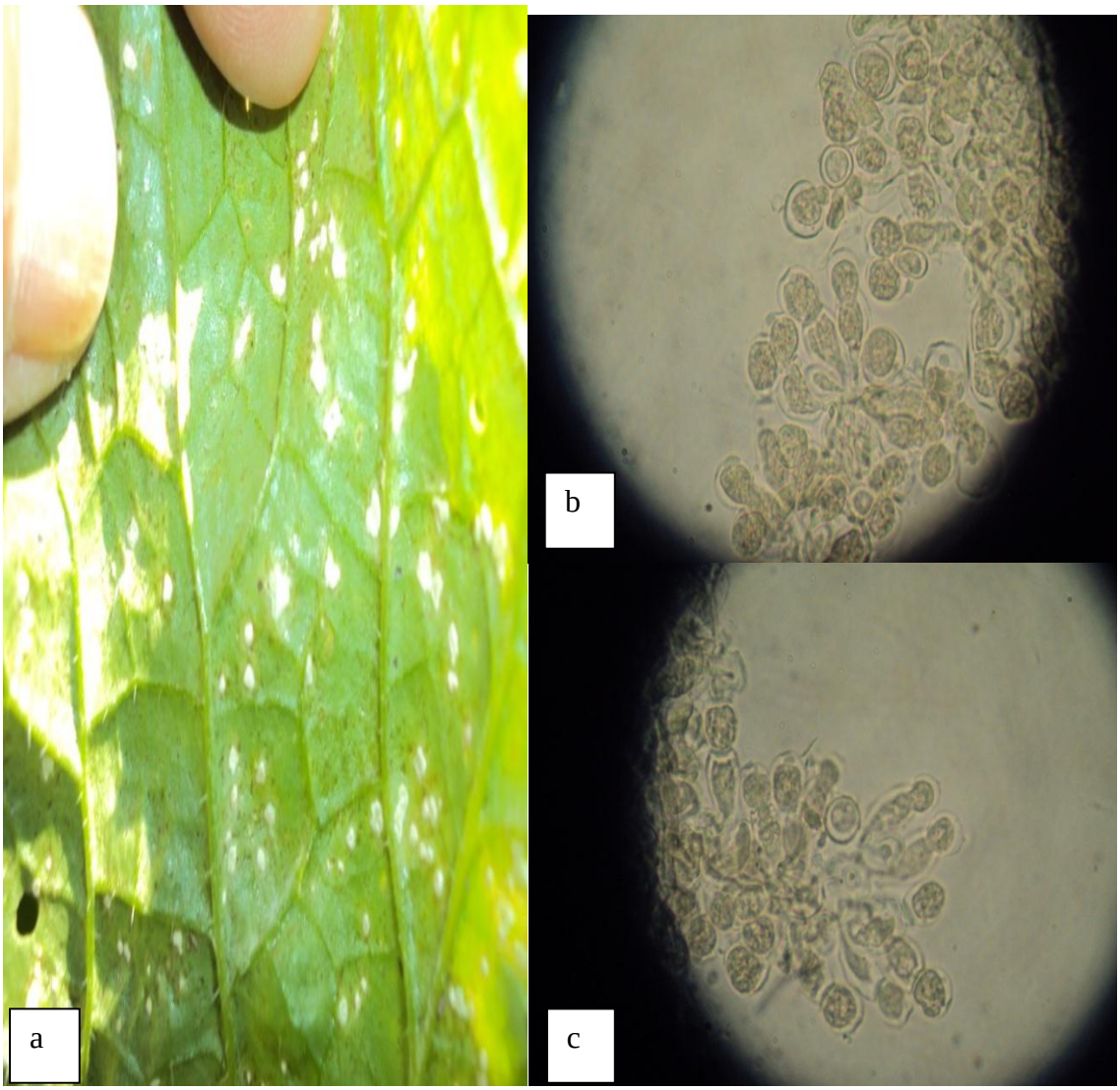

Figure 2(a). Symptoms White rust of Chinese cabbage; (b-c). Structure of white rust caused by *Albugo candida* (400x)

Powdery mildew (*Erysiphe sp*)

Among the entries, Zao Xin Bai and Dou Kang 4 had the highest infection of powdery mildew at 10% in Tulodan (high elevation) while there was no infection recorded in Natubleng, Buguias as shown in Table 6 and 7.

Table 6. Mean percentage of powdery mildew in new varieties of Chinese cabbage

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	0.00	10.00	0.00
Baguio star	0.00	2.50	0.00
Dou Kang 4	1.22	10.00	0.00
Summer star	2.80	2.00	0.00
Green cool (ck)	2.80	1.00	0.00
CV	60.52%	67.64%	0

Table 7.Disease reaction of Chinese cabbage to powdery mildew

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
Zao Xin Bai	Highly Resistant	Resistant	Highly Resistant
Baguio star	Highly Resistant	Resistant	Highly Resistant
Dou Kang 4	Resistant	Resistant	Highly Resistant
Summer star	Resistant	Resistant	Highly Resistant
Green cool (ck)	Resistant	Resistant	Highly Resistant

Mean percentage and disease reaction of different entries of Chinese cabbage to powdery mildew disease shows in Table 6 and 7. No occurrence of powdery mildew was recorded in Natubleng, Buguias. Powdery mildew disease in Chinese cabbage is not common. Infection may have occurred because the garden pea plants are near the planting site of Chinese cabbage were infected. Spores of the pathogen may have been disseminated and blown by the wind.

Among the Chinese cabbage varieties, Dou Kang 4 had the highest yield of 3.64 kilograms (3,640 g) followed by Summer Star at 2.79 kilograms (2790 g), Baguio Star at 2.51 kilograms (2510 g), Green Cool check variety at 2.43 kilograms (2,430g) and Zao Xin Bai at 2.50 kilograms (2500g).

Table 8. Total yield per plot of Chinese cabbage (kg)

ENTRY	MEAN
Cc 01 – Baguio Star	2.51
Cc 03 – Doukang 4	3.64
Green cool (ck)	2.43
Cc 06 – summer star	2.79
Cc 07 – Zao xin bai	2.30
CV	24%

Diseases of Garden pea (*Pisum sativum*)

Leaf Spot of Garden Pea

The mean percentage infection of leaf spot disease on garden pea in Cattubo, Tulodan, Atok (2,230 masl), Bonglo, Atok and BSU Balili, La Trinidad (1,332 masl) is shown in Table 9. Results revealed that the highest leaf spot infection was recorded in the variety CGP 59 with 12.50% in Bonglo, Atok (mid elevation) but had lower infection with 3.00% at lower elevation (La Trinidad). Difference among treatments however was not significant. However, results showed that leaf spot infection decreased as entries were planted at low elevation.

Leaf spot (*Cercospora sp*)

Table 9.Mean percentage of leaf spot disease in garden pea

VARIETIES	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
CGP 59	3.00	12.50	5.00
CHINESE (ck)	1.00	3.50	5.00
BETAG	1.00	1.00	5.00
CGP 34	7.50	10.00	7.50
CGP 13	0.00	4.00	5.00
CV	90.33%	33.64%	28.75%

The resistance rating of leaf spot disease in new varieties of garden pea shows in Table 10. Based from Table 9 (mean percentage), resistance rating evaluated and it revealed the corresponding remarks of new varieties in garden pea and varieties were all resistant to leaf spot. Leaf spot disease of garden pea caused by *Cercospora sp* as shown in Figure 3.

Table 10. Disease reaction of garden pea to leaf spot

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
CGP 59	Resistant	Resistant	Resistant
CHINESE (ck)	Resistant	Resistant	Resistant
BETAG	Resistant	Resistant	Resistant
CGP 34	Resistant	Resistant	Resistant
CGP 13	Resistant	Resistant	Resistant

Figure 3. Leaf spot disease of garden pea.

Powdery Mildew (*Oidium* sp.)

Powdery mildew is also a disease in garden pea. Table shows the mean percentage powdery mildew infection in garden pea planted in three agro ecological zones and Table 12 shows disease reaction of new varieties of garden pea in powdery mildew disease based on the mean percentage in Table. Figure 4 shows the structure of powdery mildew under the microscope. Result revealed that powdery mildew did not occur in Bonglo, Atok but infection of 12.50% was recorded in Tulodan Atok is variety CGP 34 showed with highest infection of 12.50% in variety CGP 34. Difference among treatments however was not significant.

Table 11. Mean percentage of powdery mildew infection in garden pea

VARIETIES	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
CGP 59	3.50	0.00	10.00
CHINESE (ck)	0.50	0.00	1.00
BETAG	0.50	0.00	4.00
CGP 34	0.50	0.00	12.50
CGP 13	1.50	0.00	3.50
CV	48.65%	0	33.64%

In terms of disease reaction, entries which were not infected in Tulodan Atok were adjudged as highly resistant. Entries with powdery mildew infection ratings of 1-25% were classified as resistant (all entries planted in Natubleng).

Table 12. Disease reaction of garden pea in powdery mildew

VARIETY	AGRO ECOLOGICAL ZONES		
	BALILI, LA TRINIDAD (Low elevation) 1,332 masl	TULODAN, ATOK (High elevation) 2,230 masl)	NATUBLENG, BUGUIAS (High elevation) 2,280 masl
CGP 59	Highly Resistant	Highly Resistant	Resistant
CHINESE (ck)	Highly Resistant	Highly Resistant	Resistant
BETAG	Highly Resistant	Highly Resistant	Resistant
CGP 34	Highly Resistant	Highly Resistant	Resistant
CGP 13	Highly Resistant	Highly Resistant	Resistant

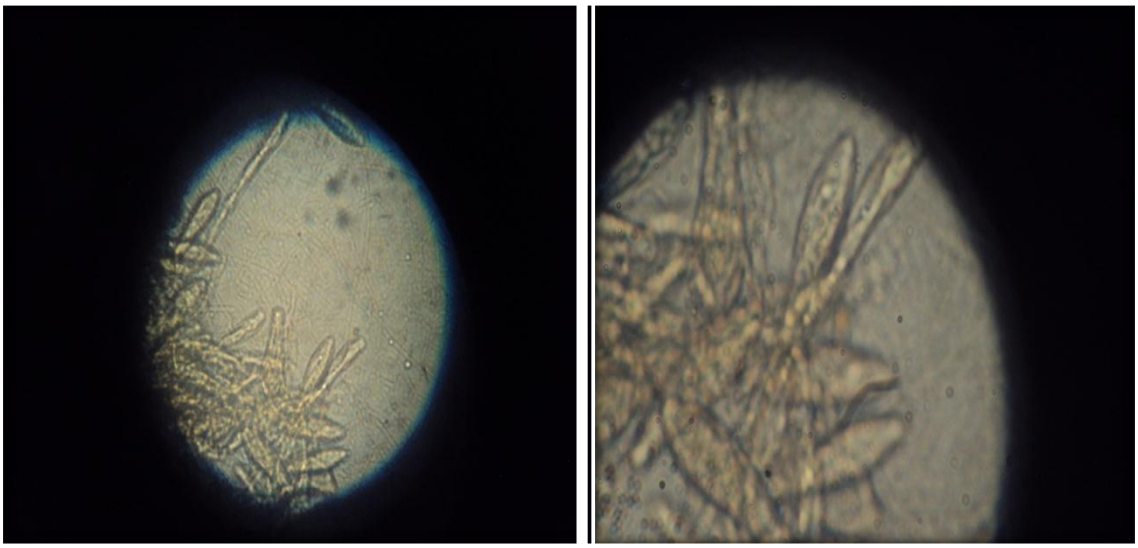

Figure 4. Structure of the causal organism of Powdery mildew in garden pea

Leaf Miner Incidence (*Liriomyza huidobrensis*)

Mean percentage leaf miner damage and reaction of garden pea planted at BSU Balili, La Trinidad is shown in Table 13. Results revealed that very low damage was recorded in all varieties as infestation only ranged from from 1.00 (no damage) to 3.50 (26-50%) damage. Minimal damage was observed because other host plants of leaf miner were not present in the field resulting to low population of the insect.

Table 13. Mean percentage and resistant rating of garden pea in leaf miner disease

VARIETY	MEAN	REMARKS
CGP 59	2.50	Resistant
CHINESE (ck)	1.00	Highly Resistant
BETAG	3.50	Moderately Resistant
CGP 34	2.00	Resistant
CGP 13	1.00	Highly Resistant
	CV= 40.31%	

Yield of Garden Pea

Table 14. Reaction of different garden pea entries to leaf miner infestation

ENTRY	MEAN
BETAG	0.33b
CGP 13	0.30b
CGP 34	0.29b
CGP59	0.82a
CHINESE (ck)	0.22b

CV	22.11

Among the entries, CGP 59 gave the highest yield of 0.82 kg followed by Betag with 0.330 kg and CGP 13 at 300 grams 0.300 kg, CGP 34 at 0.290 kg and the Chinese variety (check) had the lowest yield of 0.220 kg as shown in Table 14.

Disease of Tomato (*Solanum Lycopersicum*)

Late blight caused by *Phytophthora infestans* was the most severe disease in tomato varieties planted at Balili, La Trinidad. The disease almost destroys the whole plant. Three ratings were done to evaluate the infection of late blight in tomato. Table 15 shows the mean percentage late blight infection of tomato. Results revealed significant differences among in infection among the entries where the lowest late blight infection was recorded in CLN 2264 S3 (5%), CLN 2264 S1 (5%) and TM 10486 (15%). The highest mean infection ranged from 80% to 95 % which was recorded in the 20-05, Hong Bao Shi S2, Black Cherry, Native, Hong Bao Shi S1, TM 10491, TM 10487, CH 157, 10393, HBS, Hong Bao Shi B, CLN 1558 and TM 10485.

The disease reaction of tomato to late blight disease is shown in Table 16. Among the 24 entries, only a few entries were resistant to late blight. Variety TM 10486 was highly resistant on the first rating , resistant in the second and final rating. Varieties CLN 2264 S1 and CLN 2264 S3 exhibited resistant reaction from first to the last rating. Variety CLN 2264 B exhibited high resistance in the first rating, resistant in the second rating and moderately resistant in the last rating.

Table 15. Mean percentage of tomato in late blight disease

VARIETY	MEAN		
	1st rating	2nd rating	3rd rating
20-05	55.00[a]	70.00[abc]	92.50
TM 10492	15.00[cde]	25.00[efghi]	42.50
TM 10486	1.00[e]	15.00[ghi]	15.00
CLN 2264 S1	1.50[e]	5.00[i]	5.00
HONG BAO SHI S2	20.00[bcd]	70.00[abc]	82.50
BLACK CHERRY	3.00[e]	55.00[bcde]	95.00
NATIVE	15.00[cde]	30.00[defghi]	82.50
HONG BAO SHI S1	25.00[bc]	45.00[bcdefg]	92.50
CLN 2264 S3	5.00[e]	5.00[i]	5.00
TM 10491	30.00[b]	90.00[a]	95.00
TM 10487	12.50[cde]	72.50[ab]	82.50
CH 157	12.50[cde]	65.00[abc]	90.00
TM 10490	10.00[de]	17.50[ghi]	50.00
TM 10494	10.00[b]	40.00[cdefgh]	40.00
10393	30.00[b]	70.00[abc]	92.50
CLN 2264 B	1.00[e]	7.50[i]	30.00
HBS	15.00[cde]	60.00[abcd]	95.00
HONG BAO SHI B	7.50[de]	60.00[abcd]	95.00
TM 10488	15.00[bcd]	50.00[bcdef]	50.00
CLN1558	20.00[bcd]	55.00[bcde]	82.50
CLN2264 S2	3.50[e]	7.50[i]	37.50
CLN 1555	45.00[a]	45.00[bcdefg]	45.00
TM10493	7.50[de]	22.50[fghi]	42.50
TM 10485	10.00[de]	10.00[hi]	82.50
CV	37.16%	31.79%	90.87%

Table 16. Disease reaction of different tomato entries to late blight

VARIETY	REACTION
20-05	Very Susceptible
TM 10492	Moderately Susceptible
TM 10486	Resistant
CLN 2264 S1	Resistant
HONG BAO SHI S2	Very Susceptible
BLACK CHERRY	Very Susceptible
NATIVE	Very Susceptible
HONG BAO SHI S1	Very Susceptible
CLN 2264 S3	Resistant
TM 10491	Very Susceptible
TM 10487	Very Susceptible
CH 157	Very Susceptible
TM 10490	Moderately Susceptible
TM 10494	Moderately Susceptible
10393	Very Susceptible
CLN 2264 B	Moderately Resistant
HBS	Very Susceptible
HONG BAO SHI B	Very Susceptible
TM 10488	Moderately Susceptible
CLN1558	Very Susceptible
CLN2264 S2	Moderately Resistant
CLN 1555	Moderately Susceptible
TM10493	Moderately Susceptible
TM 10485	Very Susceptible

Variety CLN 2264 S2 exhibits resistant reaction on first and second and moderately resistant on the last rating.Varieties TM 10492, TM 10490, TM 10494, TM10488, CLN 1555, TM 10493 were resistant on first rating,moderately resistant on the second rating and exhibits moderately susceptible on the last rating. Varieties 20-05, Hong Bao Shi S2, Black Cherry, Native, Hong Bao Shi S1, TM 10491, TM 10487, CH 157, 10393, HBS, Hong Bao Shi B, CLN 1558 and TM 10485 were moderately resistant on the first rating, moderately susceptible on the second rating and turned very susceptible on the last rating.

Late blight infection shows in Figure 5 that the tomato plants were attacked by *Phytophthora infestans*. It starts as a water-soaked spots, usually at the edges of the lower leaves and enlarge rapidly. The structure of the causal organism of late blight is shown in Figure 6a and Figure 6b. It almost destroyed the whole part of the plants. The photo was taken at BSU experimental area at Balili, La Trinidad, Benguet last December 30, 2011

Figure 5. Symptoms of late blight in tomat

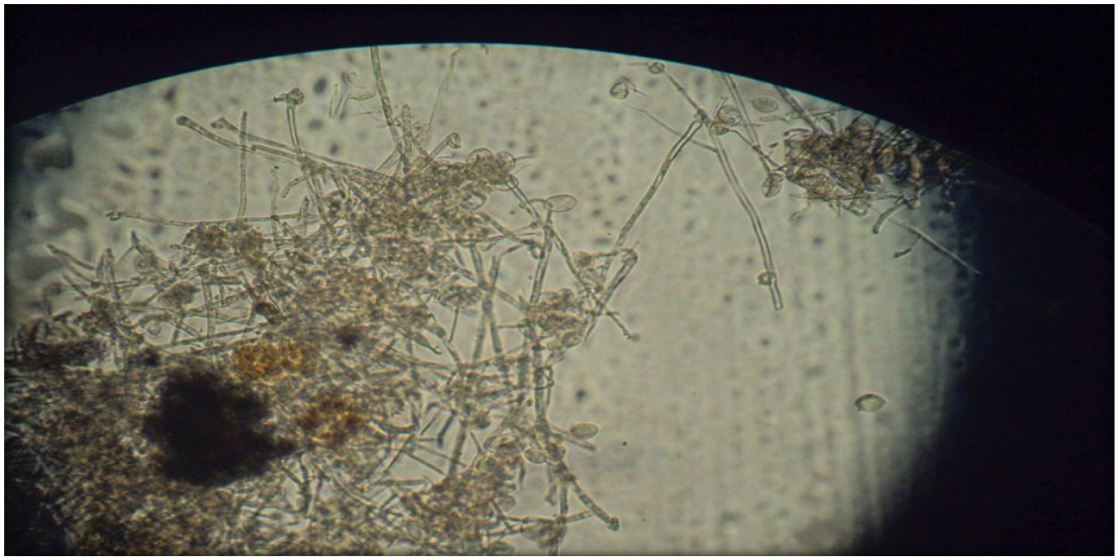

Figure 6a. Structure of the causal organism of late blight, *Phytophthora infestans* (100x)

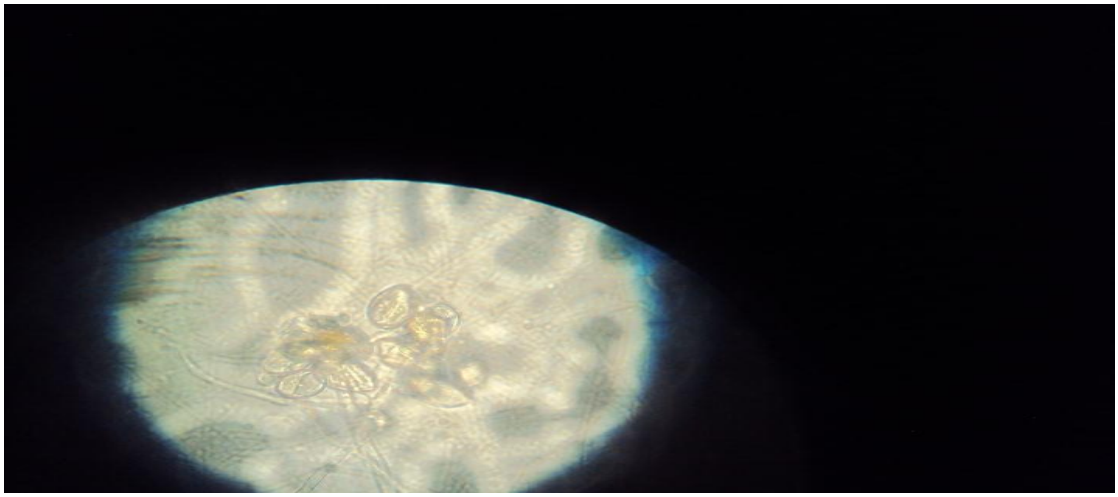

Figure 6b. The causal organism of late blight, *Phytophthora infestans* (400x)

Among the tomato entries, significantly higher yield was recorded in TM 26 (TM 10486) at 13,097.50 g/ plot followed by TM 31 at 10,331.50 g/ plot and TM 43 at 8502.00 g/ plot. Entries of tomato like TM 26 (TM 10486), TM 42 (CLN 2264 S3) and TM 43 (CLN 2264 S1) produced highest yields. Based on disease reaction, these three entries stand out because these varieties were not severely infected to late blight. As such foliage

was not heavily damaged, hence, flowers developed into fruits. Unlike heavily infection where late blight infection was high, the loss of foliage greatly affected the formation of fruits.

Table 15.Tomato total yield per plot (grams)

ENTRY	MEAN
Tm 06	1282.50 fgh
Tm 12 (ck)	7323.00 bcd
Tm 15	200.00 h
Tm 22	893.50 fgh
Tm 23	2001.50 efgh
Tm 25	4324.00 defg
Tm 26	13097.50 a
Tm 27	3113.50 efgh
Tm 29	2565.00 efgh
Tm 30	2140.00 efgh
Tm 31	10331.50 ab
Tm 32	325.00 gh
Tm 33	5410.00 cde
Tm 34	2310.00 efgh
Tm 36	908.00 fgh
Tm 37	3740.00 defgh
Tm 38	624.50 gh
Tm 39	2966.00 efgh
Tm 40	1682.50 efgh
Tm 42	4932.50 cdef
Tm 43	8502.50 bc
Tm 44	434.50 gh
Tm 45	4300.00 defg
Tm 46	473.00 gh
CV	47.74 %

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

Leaf spot disease in Chinese cabbage variety like Zao Xin Bai has least disease infection in Natubleng, Buguias and higher infection in La Trinidad and Tulodan, Atok. Variety Baguio Star has least disease infection in Tulodan, Atok and Natubleng, Buguias and higher infection in La Trinidad. Variety Dou Kang 4 has least disease infection in Natubleng, Buguias and in La Trinidad and higher infection in Tulodan, Atok. Variety Summer Star has least disease infection in Natubleng, Buguias and higher disease infection in La Trinidad. Variety Green Cool has least disease infection in Natubleng, Buguias and has higher infection in Tulodan, Atok and La Trinidad.

No occurrence of powdery mildew in Natubleng, Buguias.Powdery mildew disease in Chinese cabbage, varieties like Zao Xin Bai and Baguio Star were no disease infection in Balili, La Trinidad but occurred in Tulodan, Atok. Varieties Summer Star, Dou Kang and Green Cool has least disease infection.

No occurrence of white rust disease was recorded in Natubleng, Buguias. Varieties like Zao Xin Bai and Dou Kang 4 had higher disease infection in Tulodan, Atok but were least infected in Balili, La Trinidad. Variety Summer Star has higher disease infection in Balili, La Trinidad but had the least infection in Tulodan.

In garden pea, all varieties were highly resistant to leaf spot and powdery mildew; were highly resistant to leaf miner infestation in high agro ecological zones.

Among the tomato entries, significantly higher yield was recorded in TM 26 (TM 10486) at 13,097.50 g/ plot followed by TM 31 at 10,331.50 g/ plot and TM 43 at 8502.00 g/ plot. Entries of tomato like TM 26 (TM 10486), TM 42 (CLN 2264 S3) and TM 43

(CLN 2264 S1) produced highest yield. Based on disease reaction, these three entries stand out because these varieties were not severely infected with late blight

Conclusion

Different disease reaction was recorded in varieties of vegetables grown in organic conditions. Diseases were observed to be more prevalent in warmer area or in lower agro ecological zone than in cold and high agro ecological zone.

Recommendation

One more field trial should be done to evaluate their resistance to different diseases at different climatic conditions that occur under organic conditions. In tomato, susceptible and very susceptible entries should be culled out to lessen the 24 entries for further field trial.

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