BIBLIOGRAPHY

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Adviser: Aurora F. Pinon, Ph. D

ABSTRACT

The study was conducted to compare the efficacy of EM and Mokusako on the occurrence of soft rot (*Pectobacteriumcarotovorum*) and on two varieties of Chinese cabbage at storage. Shelf life, percentage weight loss and onset infections were recorded.

Results showed that Chinese cabbage variety F1 Champion had the longest shelf life of 17.25 days, had lower percentage weight loss of 2.80g after 15 days. On the other hand, CR Matibayhad a shorter shelf life of 16.25 days and incurred the highest percentage weight loss of 4.75g after 15 days of storage

No significant interaction was observed among the variety used. However, result showed that F1 Champion had longer shelf life. Further, results showed that variety treated with Mokusako significantly affected the shelf life and visual quality and had the lowest percentage weight loss. F1 champion had a lowest weight loss compared to CR Matibay which had the highest degree of infection after 15 days Mokusako treated variety delays the occurrence of soft rot.

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INTRODUCTION

Chinese cabbage (*Brassicapekinensis*) is a semi –temperate crop. It thrives best in cool moist area like Benguet and Mountain Province, at low elevations; it can be grown during the cool months of the year. The optimum monthly average temperature requirement of cabbage is 15.5^0C and the maximum monthly temperature should not be more than 24^0C (Bandoc, 1976).

In Philippines especially in Benguet and mountain Province this crop is also grown in commercial scale. Certainly, it is among the major source of income for the farmers.

Farmers started growing this crop many years ago but today's generation find that production of Chinese cabbage entails several problems such as premature death, non marketable yield, low quality due to poor heads also rotting of heads brought about by diseases. Among the contributory factor to such problem is the soft rot disease caused by a bacterium *Pectobacteriumcarotovorum* (Donald et al, 1997).

Soft rot caused by *Pectobacteriumcarotovorum*infects Chinese cabbage in both the field and storage. Once the crop is infected, the bacteria established it within host and can cell disintegration giving a decayed or rotten appearance. Soft rot is one of the most destructive diseases of vegetables that can cause greater total loss of produce than any other bacterial diseases (Pantastico, 1975).

Chinese cabbage is highly perishable crop. It is easily damaged due to improper handling. It is prone to diseases infection and deterioration. Being a high value commercial crop, losses due diseases like bacterial soft rot should be minimized. Because of the severe damage inflicted by soft rot, farmers initially spray pesticides but the practice does not actually control the diseases very few chemical treatments effectively control bacterial diseases in the seedbed or field condition. The inherent toxicity of most existing chemical pesticides to non-target organic and their persistence in the environmental has gained interest on researched efforts to find alternative and more environmentally friendly methods of controlling pest and diseases (Woodman, 2006).

The trial on the use of effective microorganism (EM) was evaluated in this study. Effective microorganism (EM) is in liquid form and consists of naturally occurring beneficial microorganisms. The microbes in EM are non-harmful, non-pathogenic, not-genetically-engineered or modified (non-GMO), and not-chemically-synthesized, and EM is not a medicine either. The basic groups of microorganisms in EM are lactic acid bacteria (commonly found in yogurt, cheeses), yeast (bread, beer), and phototrophic bacteria. EM is being used successfully in the field of agriculture, fisheries, poultry, and animal husbandry and for the preparation of compost and Bokashi. It has no harmful effects to humans or animals and it's environmentally friendly (Kyan, 1990).

A newMokusakois a traditionalJapanese land improver which is collected by of cooling the exhaust smoke of charcoal kilns when burning the wood material. It contains 200 types of organic minerals which is good for plants it is a pure wood vinegar. Theproducts originated from Japan and were proven to be effective as fertilizer and pesticide; however, a trial on our country is necessary.

This study was conducted to compare the efficacy of EM and Mokusako on the occurrence of soft rot (*Pectobacteriumcarotovorum)* in the two variety of Chinese cabbage and to determine the percentage weight loss, Shelf life and Visual quality in the two variety of Chinese cabbage caused by bacterial soft rot.

The study was conducted in Plant Pathology Department, Benguet State University, La Trinidad Benguet. FromSeptember 2011 to February 2012.

REVIEW OF LITERATURE

The Crop

Chinese cabbage also known as “Petchay Baguio” or “wombok” belongs to the group of cultivated varieties of the species *Brassicas* or the “Cole crops”. It is an herbaceous Biennial, Dicotyledonous plant having an elongated head of overlapping, crinkled, broad stalk leaves and eaten as a vegetables in Asian cuisine. It is indigenous to China where it had been grown for its leaves which is a good source of vitamins C and Calcium but low fat calories (PCCARD, 2005).

Chinese cabbage ranks second to potato in importance as vegetable and cash crop in Benguet and Mountain Province. Around 3,000 hectares are planted annually to Chinese cabbage alone in Benguet Province. Chinesecabbage plays a very important role in human life being used as vegetable, oil crops, forage crops and sources of vitamin C and A (Bulangao, 1998).

The Disease

Soft rot disease caused by *Pectobacteriumcarotovorum* has a very wide host range infecting large number of vegetable species belonging to different families. Crucifers are susceptible to bacterial soft rot which include cabbage, cauliflower, Brussels sprouts kohlrabi, turnip, radish, horseradish and rutabaga. The host range includes genera from all the plants families of vegetables, fruits and ornamentals, nearly about sixty-four plant species are susceptible to the disease (Walker, 2004 and Anonymous, 1990).

Symptoms

The disease has the same appearance on each host. The affected tissue becomes soft and slimy without much discoloration, but often accompanied by an offensive smell. Soft rot symptoms begin as small water soaked lesion that enlarges rapidly. The affected area becomes soft and mushy while its surface becomes discolored and somewhat depressed tissue within affected region becomes slimy (Ware, 1937).

On Chinese cabbage, bacterial soft rot is quite common in the field as this crop is particularly susceptible. Symptoms first appear on leaves as small water soaked lesions. The affected tissue becomes soft and mushy with an accompanying foul smell. Eventually the leaves, stems and roots are entirely decayed by the bacteria (Johnson, 1999).

Cruciferous plants and onions infected by soft rot bacteria, always give off a repulsive odor. When root crops are affected in the field the lower parts of the stem may also become infected, watery, may turn black and shrivel, causing the plants to become stunted, wilt, and die. Infections of succulent leaves and stems are seldom important in the field (Agrios, 1997).

Life Cycle of the Pathogen

The soft rot bacteria survives in infected fleshy organs in the field and in storage, in debris, on roots or other parts of host plants, in pods and streams use for water irrigation water, occasionally in the soil, and in the pupae of several insects. The disease may first appear in the field on plants grown from previously infected seed pieces. Some tubers, rhizomes, and bulbs become infected through wounds or lenticels after they are set or formed in the soil. The inoculation of bacteria into fleshy organs and their further spread in storage and in the field are greatly facilitated by insects. The soft rot bacteria can live in all stages of insect's vector. Moreover, the bodies of the insect larvae (maggots) become contaminated with bacteria when they crawl about on rotting seed pieces, carry them to healthy plants, and disseminate into wounds where they can cause the disease. Even when the plants or storage organs are resistant to soft rot and can stop its advance by formation of wound-cork layers, the maggots can destroy the wounds cork as fast as it is formed, and the soft rot continuous to spread (Agrios, 1997).

Porombelon (1999) stated that *Pectobacteriumcarotovorum* is a plant pathogen belonging to the family Enterobacteriaceae. It is non-spore forming and peritrichously flagellated. *P. carotovorum* causes death by creating an osmotically fragile cell. It produces extracellarpectic enzymes that destroy the integrity of the pectin. To a lesser extent, it produces extracellular cellulose to degrade cellulose. Other exported enzymes thought to be important in pathogenesis include hemicellulases, arabanases, xylanases and a protease.

Pectobacteriumcarotovorum are straight rods, non- spore forming, 0.5 – 1 x 1- 3 microns occurs singly; motile withperitrichous flagella. Gram negative, facultative anaerobic; catalyses positive, oxidase negative, urease not produced by the bacterium. Acid is produced from D (+) glucose, D (+) hydrolyzed but the bacterium readily hydrolyses gelatin and pectin. Optimum temperature for *Pectobacteriumcarotovorum* ranges from 27-30^{0}C maximum varies from 32-40^{0}C (Bradbury, 1989).

Postharvest Losses

Improper harvesting and rough handling at the farm directly affect market quality. Bruises and injuries later show up as brown and black patches making commodities unattractive, some physiological disorders are attributed to improper handling Injuries may serve as avenues for the microorganisms entry and lead to rotting, moreover, respiration is increased remarked by the damages, injuries and storage life is thus shortened (Pantastico, 1975).

Pantastico, 1975 also stated that postharvest losses could be attributed to mishandling at harvest and losses due to diseases especially soft rot caused by *Pectobacteriumcarotovorum*. Recent studies show that 60-70% of vegetables being produced are wasted due to improper postharvest handling and diseases, 30-40% of vegetables are wasted due to decay, injuries, streaming and sprouting among all these factors, weight loss is the most estimable form of loss after harvest. Although proper cultural management of the crops has received so much attention, proper postharvest handling seems to be neglected by traders as well as farmers.

Loss from physiological shrinkage is often much more serious from the economic stand point. Most vegetable loss from decay organisms is lessened as the temperature is lowered, with few exemptions. This means the storage area should be kept low for most commodities without allowing it to freeze. Most vegetables freeze at temperature varying from -2.22 to 11.1^{o}C (Work and Crew, 1937).

Storage products prolonged usefulness and some cases maintain their quality storage life may be prolonged by proper control and management of postharvest diseases, regulation of temperature (Pantastico, 1975).

Control

The control of bacterial soft rot of vegetables is based almost exclusively on sanitary and cultural practices. In the field, plants should be planted in well-drained areas and at sufficient distances to allow adequate ventilation. Susceptible plants should be rotated with cereals or other non-susceptible varieties. Few varieties have any resistance to soft rot and no variety is immune. Chemical sprays are generally not recommended for the control of soft rot. Control of insects that spread the disease reduces infections both in the field and in storage (Agrios, 1997).

Mokusako

Mokusako (wood vinegar) is a liquid obtained from the smoke when wood is heated to produce charcoal consists of gases and vapor generated from heated wood. When smoke is cooled in a pipe, it is condensed to a liquid and drips down the pipe. The collected liquid is now the Mokusako. Mokusako helps in the fermentation process to compost materials. It eliminates noxious microorganisms and enhances useful ones to propagate. Organic materials contained mokusaku becomes nutrients to plants microorganisms. It is also effective when it is used fertigate the soil around the plants (Yokomori, 2009). Mokusaku is not an agricultural chemicals but it may be used as a supplementary material. It controls some diseases such as soft rots. It can also be used as insect repellent and foliar spray to let the plant leaves thicker, stems sturdier and increasing plants resistance to pest and diseases (Yokomori, 2009).

Japanese product mokusako used as pesticide and fungicide was reported to be effective in their crops. The expansion of the said mokusako users reaches the municipalities of Benguet like Atok, Buguias, Kabayan, Kibungan, La Trinidad, Tuba and Tublay (Catajan, 2010).

Effective microorganism (EM)

Effective Microorganism (EM) or kyuse isa microbialinoculants. It is a mixed culture of beneficial microorganisms (primarily photosynthetic and lactic acid bacteria, yeast, actinomycetes and fermenting fungi that can be applied as inoculants to increase the microbial diversity of soils. This is turn, can improve soil quality and health, which enhances, yield and quality of crops. In crop culture, EM increases the metabolic, biological activities in the soil and photosynthetic abilities of plants (Danigos, 1996).

Effective Microorganisms (EM) is a living entity containing active microbes that helps to enhance beneficial microbes in the soil. It can also be mixed to any compost for fast decomposition. It improves the soil by producing ideal microorganisms which increases soil fertility for plant growth.

The used of EM in agriculture have many significant beneficial impacts. The most researched and stated are as follows: 1. EM promotes germination, growth, flowering, fruiting and ripening in crop plants. It enhances the photosynthetic capacity of plants. And EM increases the efficacy of organic matter as fertilizers. Furthermore, EM develops resistance of plants to pest and diseases. EM suppresses soil borne pathogens and pests it improves the physical, chemical and biological environments of the soil, and enhances crop yields in organic systems in most environments. It also develops the soil, to improve its ability to sustain crops.

Effective microorganisms 5 (EM5)

Effective Microorganisms5 (EM5) is a non-toxic chemical free insect repellent. It can also be used to prevent pest and disease problems in crops. It acts by creating a barrier around the plant, thereby protecting it from insect pests and diseases (Kyan, 1990).

MATERIALS AND METHODS

Two effective microorganisms (EM1 and EM5) and Mokusako obtained from the Municipal Agriculture Office (MAO) of La Trinidad were tested for the control of soft rot in two varieties of Chinese cabbage, CR Matibay and F1 Champion which are newly harvested and free from pest and diseases with uniform sizes and stages of maturity.

Fresh specimen of bacteria (*Pectobacteriumcarotovorum)* was isolated in the laboratory following the streak methods for bacterial isolation. Bacterial suspension was prepared from a day old culture with 10ml distilled water and surface was scraped withsterilizwwireloop. Chinese cabbage of uniform sizes and stages of maturity were inoculated with the bacterial suspension at butt end. EM and Mokusakowere sprayed directly at the butt ends of Chinese cabbage (F1 Champion and CRMatibay).

The treatments were individually packed with plastic cellophane and arranged in a completely randomized design (CRD) involving 2 factor type of variety as Factor A and EM and Mokusako treatment as Factor B.

Each treatment combination was replicated three times with three heads per replication or a total of nine samples per treatment combination.

The treatments are as follows:

Factor A- Type of variety

V_1- Cr Matibay

V_2- F1 Champion

Factor B- EM and MokusakoTreatments

T_0- Control

T_1-Mokusaku

T_2-EM1

T_3-EM5

Data gathered

The following data and information were gathered to compare the efficacy of EM and Mokusako on the incidence of bacterial soft rot on Chinese cabbage varieties CR Matibay and F1 Champion.

1. Shelf-life. The numbers of days the produce remained were not acceptableto consumer

2. Percentage of weight loss.

$$\text{Percentage of weight loss} = \frac{\text{Initial weight- finalweight}}{\text{Initial weight}} \text{X } 100$$

3. Percentage of head infected with soft rot.

$$\text{\%Soft rot incidence} = \frac{\text{Total no. of heads-No. of heads with soft rot}}{\text{Total no. of heads per treatment}} \ 100$$

4. Visual Quality. This refers to the quality variations in the appearance of Chinese cabbage

9- Excellent, Field fresh.

7-8= Very good, slight defects

5-6= Good moderate defects.

3-4= poor, defects increasing, need trimming.

1-2= poor, limit of sale ability

5. Number of days to initial infection. The number of days to first occurrence of soft Rot at butt-ends or other parts of Chinese cabbage variety.

6. Degree of Infection. This refers to the infection of soft rot in cabbage. The rating scale tools used were the following:

Rating Scale	Description of Infection
1	No Infection
2	1-19% of surface area infection
3	20-39% of surface area infection
4	40-60% of surface area infection
5	>60% of surface area infection

RESULTS AND DISCUSSION

Shelf life

Effect on Variety. The effect on the varieties shelf life is shown in Table1. Result revealed that F1 Champion had longer Shelf life of 17.25 days compared to Cr Matibay which had 16.25 days.

Table1. Shelf life

Variety	SHELF LIFE (DAYS)
Cr Matibay	16.25[a]
F1 Champion	17.25[a]
Treatment	
Control	15.17[b]
Mokusaku	17.67[a]
EM1	17.33[a]
EM5	16.83[a]

Means with the same letter are not significantly different at 5% level using DMRT.

INTERACTION

Treatment	Variety: CR Matibay	F1 Champion
Control	14.66	15.66
Mokusako	17.00	18.33
EM1	16.66	18.00
EM5	16.66	17.00

Effect of treatments. The different treatments significantly affected the shelf life of Chinese cabbage varieties. Variety treated with mokusako had the longest shelf-life of 17.67 days followed by the crops treated with EM1 with a mean of 17.33 days. Control showed the shortest day of shelf life with a mean of 15.17 days.

These results revealed that using mokusako and EM1 can prolonged the shelf life of the commodity. Longer shelf life on the varieties of Chinese cabbage which treated was might due to their resistance against soft rot.

Interaction effect. There were no significant interaction effect observed between the treatments and variety used.

Visual quality

Effect on Variety. Results showed that Cr Matibay had the lower visual quality rating of 5.58 followed by F1 Champion which had a mean of 6.08 which is good and moderate defects. As shown in figure 1 and 2.

Effect of treatments. It was observed that variety treated with Mokusakuosignificantly delayed the deterioration of the quality both F1 Champion and Cr Matibay in the yellowing of leaves and shriveling than the untreated variety. Variety treated with Mokusako with a mean of 6.83 was the latest to show poor visual quality rating after 15 days of storage compared to the untreated variety that had a mean rating quality of 3.50 was the earliest to show poor visual quality.This is significantly different to other treatments.

Interaction effect. F1 champion treated with Mokusako were the latest to show deterioration with visual quality rating which is good and moderate defects after 15 days. However, Statistical analysis revealed no significant interaction.

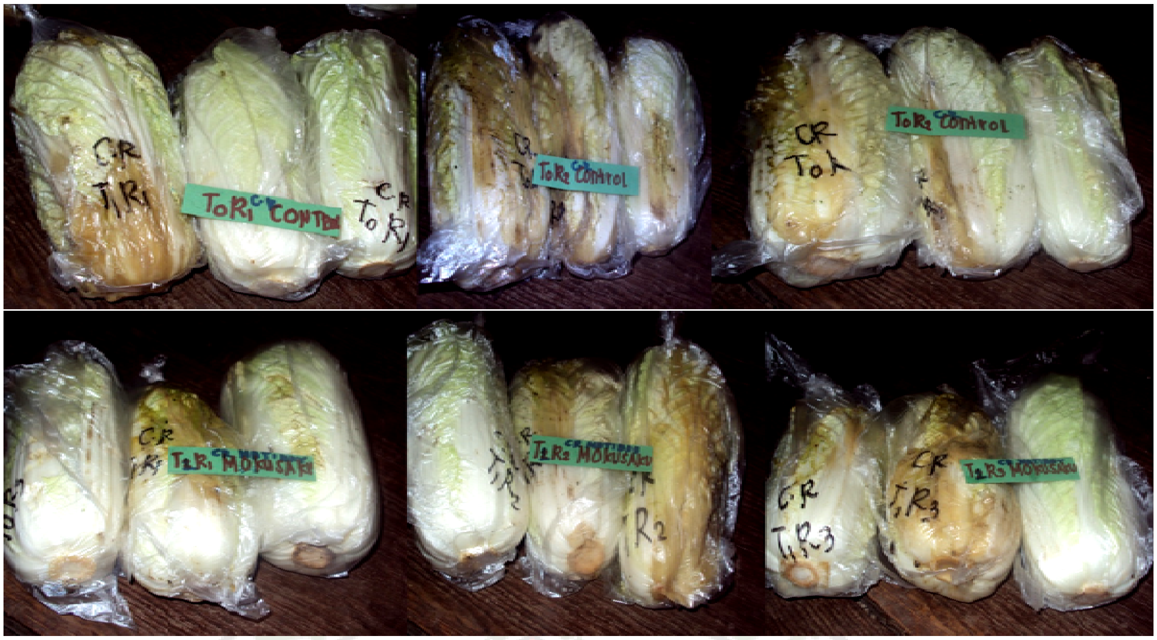

Figure 1 a. Visual Quality of CR Matibay 15 DAI

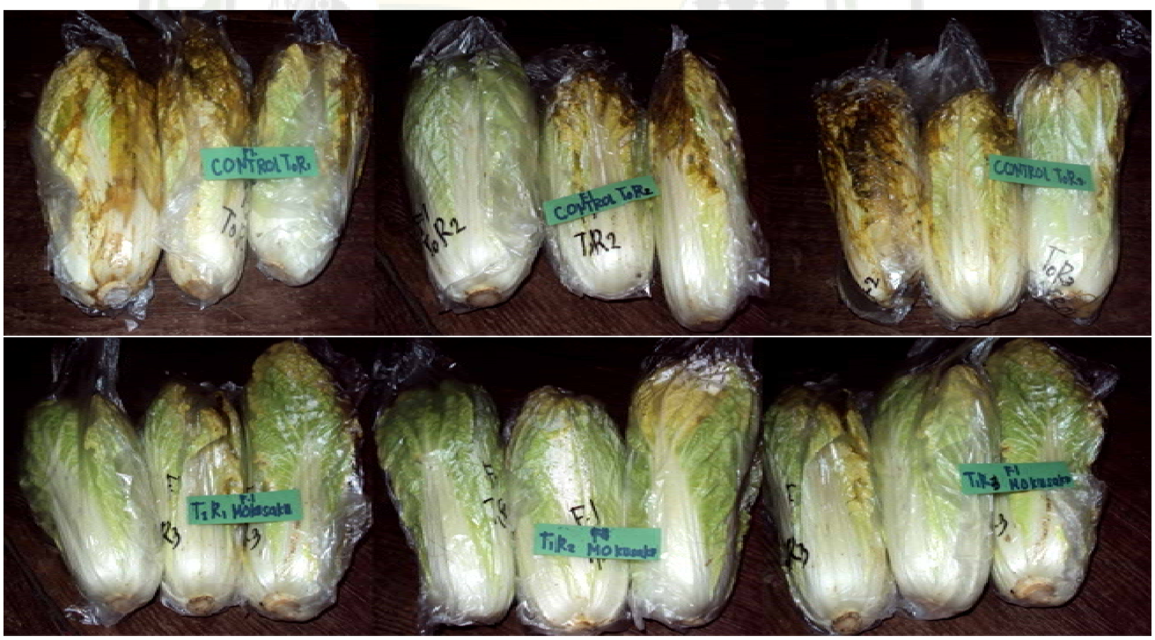

Figure 2. Visual Quality of F1 Champion 15 DAI

Table 2. Visual quality rating (15 DAI)

Variety	Visual Quality Rating
Cr Matibay	5.53[a]
F1 Champion	6.03[a]
Treatment	
Control	3.50[b]
Mokusaku	6.83[a]
EM1	6.67[a]
EM5	6.33[a]

Means with the same letter are not significantly different at 5% level using DMRT.

INTERACTION

Treatment	Variety CR MATIBAY	F1 Champion
Control	3.33	3.67
Mokusako	6.67	7.00
EM1	6.33	7.00
EM5	6.00	7.00

Percentage Weight Loss due to *Pectobacteriumcaratovorum*

Effect of Variety. Table 3 showed that the percentage weight loss on the varieties after 5, 10 to 15 days. F1 Champion consistently showed a lower percentage weight loss of 2.80g after 15 days as compared to CR Matibay of 4.75g after 15days during the duration of the experiment, statistical analysis revealed no significant differences between the two varieties

Table 3.Mean Weight Loss(g)

Variety	Weight loss (%) after 5days	10days	15 days
Cr Matibay	1.19^{a}	2.75^{a}	4.75^{a}
F1 Champion	0.74^{a}	2.18^{a}	2.80^{a}
Treatment			
Control	1.25^{a}	3.46^{a}	4.33^{a}
Mokusaku	0.78^{a}	2.86^{a}	2.35^{a}
EM1	0.73^{a}	2.50^{a}	3.63^{a}
EM5	0.95^{a}	3.05^{a}	3.80^{a}

Means with the same letter are not significantly different at 5% level using DMRT.

INTERACTION

Treatment	Weight loss after (g) 5days V1	V2	10 days V1	V2	15 days V1	V2
Control	2.17	0.67	4.17	2.75	5.12	3.55
Mokusako	1.27	0.28	3.83	1.88	2.67	2.03
EM1	0.60	0.85	3.67	1.32	5.07	2.09
EM5	0.73	1.22	3.33	2.77	4.06	3.53

Effect of EM and Mokusako. Weight loss assessments of Chinese cabbage heads treated with Mokusako, EM1 and EM5 is shown in Table3.

The control had the highest weight losses at 5, 10 and 15 days of storage. The lowest weight loss was obtained from those treated with EM1 at 5 days with a mean of

0.75g and Mokusakoat 15 days with a mean of 2.35. However, statistical analysis is not significantly different to each other.

Interaction effect. Results showed that there was no significant effects observed between the varieties and treatment the different treatment used. Although, both of the variety was comparable to each other, this may imply that weight loss might not be affected regardless on the treatment used.

Number of days to initial infection

Effect of variety. The effect of variety on the number of days to initial infection is shown in Table 4. Results revealed that F1 champion showed the latest initial infection at butt-end and other parts of head with a mean of 8.33 days compared to CR Matibay which had a mean of 7.75 days. The variety that is untreated showed the earliest infection at butt-end and other parts of its head. F1 Champion is less infected with *Pectobacteriumcarotovorum* than CR Matibaywhich showed an earliest infection with the pathogen leading to rapid breakdown.

Effect of EM and Mokusako. Statistically, there were significant differences observed on the number of days to initial infection at butt-end and other parts of head. Variety treated with Mokusako was the latest to show initial infection after 8.83 days followed by EM1 with a mean of 8.50 days and the untreated one showed the earliest infection with a mean of 7.170 which is significantly different to the other treatments.

Interaction effect. The combined effect on the variety and the different treatments used affect the number of days to initial infection. F1 Champion treated with mokusako was the latest to show initial infection at butt-end.

Table 4. Number of days to initial infection at butt-end and other parts of the head

Variety	Mean
Cr Matibay	7.75[a]
F1 Champion	8.33[a]
Treatment	
Control	7.17[b]
Mokusaku	8.83[a]
EM1	8.50[a]
EM5	7.67[a]

Means with the same letter are not significantly different at 5% level using DMRT.

INTERACTION

Treatment	Variety	
	CR MATIBAY	F1 Champion
Control	7.00	7.33
Mokusako	8.86	9.00
EM1	8.00	9.00
EM5	7.33	8.00

Degree of Infection.

Effect of variety. Table 5 showed the mean soft rot rating on the two variety of Chinese cabbage. Results revealed that CR Matibay obtained the highest mean rating of 4.15 compared to F1 Champion which has a mean rating of 4.05 however, revealed nosignificant differences between the two varieties.However, statistical analysis revealed no significant interaction.

Among the treatment used, variety treated with Mokusako was the latest to show infection at butt-end with a mean of 3.75 followed with those treated with EM1 with a mean of 4.33.This shows that higher degree of infection had already attacked by soft rot.

Table 5. Degree of infection

Variety	Rating
Cr Matibay	4.15[a]
F1 Champion	4.05[a]
Treatment	
Control	4.50[a]
Mokusaku	3.75[b]
EM1	4.33[a]
EM5	4.37[a]

Means with the same letter are not significantly different at 5% level using DMRT.

INTERACTION

Treatment	Variety: CR MATIBAY	F1 Champion
Control	4.67	4.00
Mokusako	3.75	3.75
EM1	4.00	3.50
EM5	4.33	4.50

Interaction Effect. There were nosignificant interaction effect between the treatments usedhowever; Variety treated with Mokusko show the lowest degree of infection.

Percentage of Heads Infected with Soft Rot

Effect on Variety. Results revealed that F1 champion and CR Matibay had the same mean percentage of heads infected with soft rot of 78.70% after 20 days which is significantly different with each other.

Effect of EM and Mokusako. Table 6 showed the effect of EM and Mokusako in the percentage of head infected with soft rot was significant.

Among the treatments used the variety (F1 Champion) treated with Mokusako had the lowest percentage infection of soft rot with a mean of 66.67% which is significantly different of the other treatments.

Interaction effect. Result implies that using Mokusako on the varieties of Chinese cabbage heads could decreased the respiration rates, thus delayed the occurrence of soft rot that leads to longer shelf life of the variety stored.

Table 6.Percentage of heads infected with soft rot

Variety	Head Infection (%)
Cr Matibay	78.70[a]
F1 Champion	78.70[a]
Treatment	
Control	83.33[b]
Mokusaku	66.67[a]
EM1	83.32[a]
EM5	81.47[a]

INTERACTION

Treatment	Variety CR MATIBAY	F1 Champion
Control	81.46	85.18
Mokusako	66.67	66.67
EM1	81.47	77.77
EM5	85.17	81.17

Means with the same letter are not significantly different at 5% level using DMRT

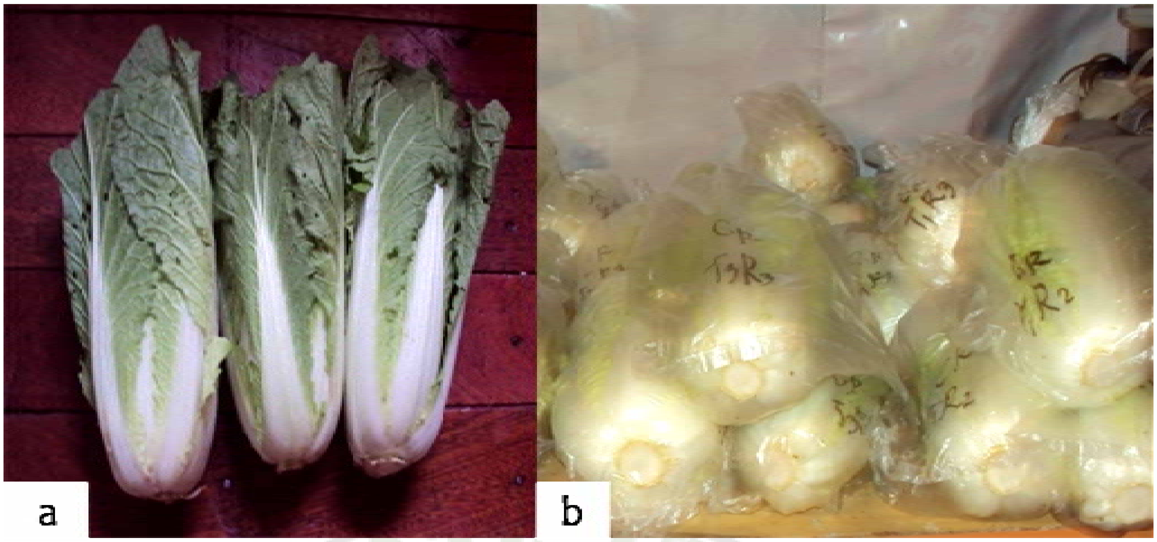

Figure3 a. Morphological characteristics of CR Matibay
b. Expiremental set-up of CR Matibay one day after inoculation.

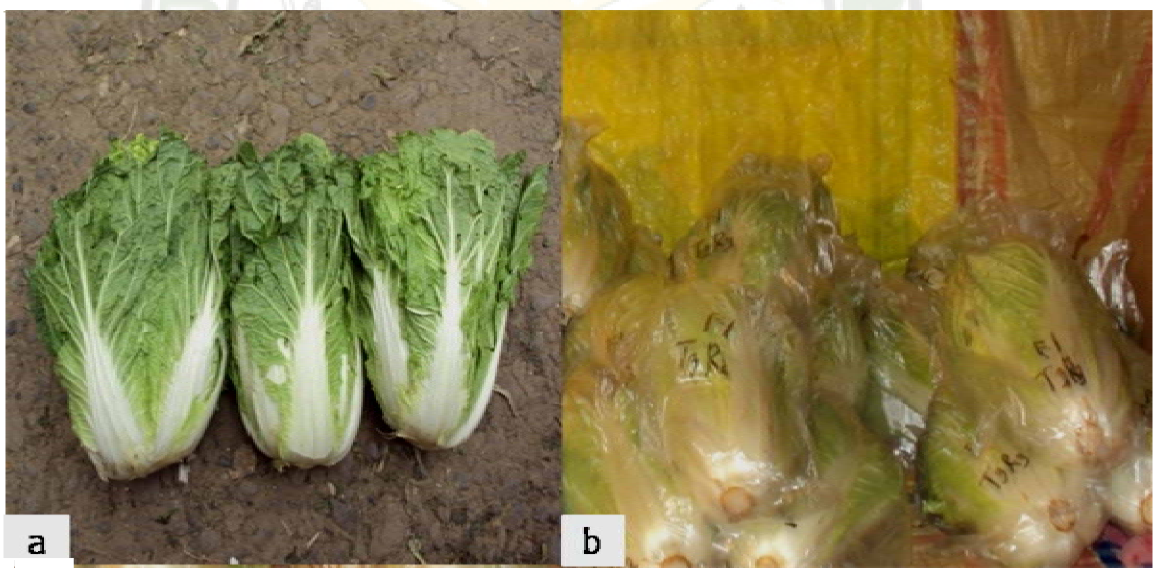

Figure4 a. Morphlogical characteristics of F1 Champion
b. Expiremental set-up of F1 Champion one day after inoculation.

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The treatments used against soft rot on Chinese cabbage at storage were:Mokusako, EM1 and EM5. These treatments were sprayed directly on butt-ends of Chinese cabbage.

Results of the study revealed that there were no significant interaction between treatments and variety treated used in terms of weight loss percentage. Although all treatments used affected the percentage weight loss of the variety; conversely untreated shows the highest mean weight loss after 15 days. It also enhanced the shelf life and delayed the occurrence of soft rot on 2 the varieties used.

Conclusion

Based on the results there is significant effect that occurred between the variety and the treatment with respect to shelf life, visual quality rating and soft rot infection although Mokusakodelayed its early occurrence and had longer shelf life during storage.

Variety treated with Mokusako retained its good quality which had a moderate defect after termination of the study, enhanced postharvest shelf life and delayed the occurrence of soft rot. Among the variety used F1 Champion is more resistant against soft rot unlike CR Matibay that can easily attacked by the organisms.

Recommendation

It is therefore recommended that Mokusako can be used to control soft rot of Chinese cabbage at storage effectively to delay the occurrence of soft rot and it could be used to prolonged visual quality and enhanced a longer shelf life of the commodity during storage. It is also recommended that follow- up studies must be conducted to verify the results generated.

LITERATURE CITED

AGRIOS, G.N.1997. Plant Pathology.4th Edition. Academic Press Inc., USA. Pp. 434-437

ANONYMOUS. 1990. Postharvest Decay of Bell Paper. Bacterial Soft rot .Retrieved October 10, 2010 from http:// www.Highland fresh.Net /tb-pepper-intro.html.

BULANGAO, L.T. 1998. Pathogenicity test of *Plasmodiophorabrassicae* on Chinese cabbage Head.UnpublishedThesis.Benguet State University. La Trinidad,Benguet. P.1

BANDOC, G.B. JR. 1976 Cabbage Cauliflower and Broccoli Vegetable production in Southeast Asia.University of the Philippines, Los Banos, Laguna. 147p.

BRADBURY, J.F. 1989. *Erwiniacarotovora*,GuidetoPlant pathogenicBacteria. CAB International Mycological Institute, Newyork. Pp67. Retrieved October 21, 2010 from http://www.avrdc.org./LC/Cabbage/softrot.html.

CATAJAN, M.E. 2010. Wood Vinegar to be used in Farming. Retrieved November 10, 2010 from www.sunstar.com.ph/baguio/wood -vinegar-is-used-farming.

DANIGOS, E.P. 1996. Effect of Bokashi and EM1 on the Incidence of Bacterial Wilt *(Pseudomonas solanacearum*) on White Potato .Unpublished Thesis.Benguet State University. La Trinidad, Benguet. P.22.

DONALD, E.C.I.J. PORTER.R.FAGGIAN ANDR.LANCASTER.1997 Towards integrated control of clubroot.Field evaluation of treatments for clubroot control. In: programme and summaries brennial conf.11th Australian Plant Pathology Society, Perth.P. 38

JOHNSON, S. 1999. Blackleg and Bacterial Soft rot.PotatoFacts.Bulletin No. 2493. University of main.(AVRDC.Bacterial soft rot.Retrieved October 27, 2010 from http:// www.avrdc.org./LC/Cabbage/soft rot.html.

KYAN, T. 1990. Kyusei Nature Farming And Technology of Effective Microorganisms. Asia Pacific Natural Agriculture Network, Bangkok, Thailand. Pp. 6-7.

PANTASTICO, E. 1975.Postharvest Physiology, Handling and Utilazation of tropical and subtropical Fruits and Vegetables. Westport, connection: The Avi Publishing Co. 547p.

PHILIPPINECOUNCILFOR AGRICULTUREFORESTRY and NATURAL RESOURCES RESEARCH and DEVELOPMENT. 2005. Soft rot of Chinese cabbage review of literature. Retrieved October 12, 2011 from http;// www.Pccarrd.dostgov.ph.

POROMBELON, M.CM.1999. The Prokaryotes. 2nd ed.RetrievedOctober 29, 2010fromhttp;//web.msl.Edu/microbio/bio221-1999/Ecarotovora,html.P. 2899

WALKER, J.C. 2004.Bacterial soft rot.In manual of vegetable plant diseases, chupp, c. (ed).Shriti book distributors. New Delhi. Retrieved November 05, 2010 from http;//www.highlandfresh.Net/tb pepper intro.html.

WOODMAN, H.M. 2006.“Cabbage leaves are poor man’s poultice”. British Medical journal. Retrieved November 05, 2010 from http;//www.bmj.com/cgi/content/full327/7412/451-c

WARE. G. W. 1975. Vegetable Crops. Danville. Illinois’. The Intersate Printers And Publication. Inc. Pp. 277

WORK, and CREW.1975.Vegetable Productionand marketingNew YorkState College of Agriculture. P. 48

YOKOMORI, M, 2009, Safe and Healthy Vegetables for Philippine Consumers, Japan International Cooperation Agency.P. 4.

APPENDICES

Appendix Table 1. Shelf life

TREATMENTS	REPLICATION			TOTAL	MEAN
	I	II	III		
V_1T_0	14	15	15	44.00	14.67
V_1T_2	16	17	18	51.00	17.00
V_1T_3	16	16	18	50.00	16.67
V_1T_4	16	17	17	50.00	16.67
SUBTOTAL	62	65	68	195.00	65.00
V_2T_0	16	15	16	47.00	15.67
V_2T_1	18	19	18	55.00	18.33
V_2T_2	17	19	18	54.00	18.00
V_2T_3	17	17	17	51.00	17.00
SUBTOTAL	68	70	69	207.00	69.00

Two-Way Table

TREATMENT	VARIETY		TOTAL	MEAN
	V_1	V_2		
T_O-Control	44	47	91	15.17[b]
T_1-Mokusaku	51	55	106	17.67[a]
T_2-Em1	50	54	104	17.33[a]
T_3-Em5	50	51	101	16.83[a]
TOTAL	195	207	402	
MEAN	16.25[a]	17.25[a]		16.75

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	6.000	6.000	10.2857[ns]	3.24	5.29
Factor B	3	22.167	7.389	12.6667**		
AB	3	1.000	0.333	0.5714[ns]		
ERROR	16	9.333	0.583			
TOTAL	23	38.500				

** = highly significant CV=4.56%
ns = not significant

Table 2. Visual Quality

TREATMENTS	REPLICATION I	II	III	TOTAL	MEAN
V_1T_0	3.00	4.00	3.00	10.00	3.33
V_1T_2	8.00	6.00	6.00	20.00	6.67
V_1T_3	6.00	5.00	8.00	19.00	6.33
V_1T_4	6.00	7.00	5.00	18.00	6.00
SUBTOTAL	23.00	22.00	32.20	67.00	22.33
V_2T_0	4.00	3.00	4.00	11.00	3.67
V_2T_1	6.00	8.00	7.00	21.00	7.00
V_2T_2	7.00	6.00	8.00	21.00	7.00
V_2T_3	6.00	7.00	7.00	20.00	7.00
SUBTOTAL	23.00	24.00	26.00	73.00	24.33

Two-Way Table

TREATMENT	VARIETY		TOTAL	MEAN
	V_1	V_2		
T_O-Control	10.00	11.00	21.00	3.50[b]
T_1-Mokusaku	20.00	21.00	41.00	6.83[a]
T_2-Em1	19.00	21.00	40.00	6.67[a]
T_3-Em5	18.00	20.00	38.00	6.33[a]
TOTAL	66.00	73.00	140.00	
MEAN	5.50[a]	6.08[a]		5.83

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	1.500	1.500	1.5652[ns]	3.24	5.29
Factor B	3	44.333	14.778	15.4203[**]		
AB	3	0.167	0.56	0.0580[ns]		
ERROR	16	15.333	0.958			
TOTAL	23	61.333				

** = highly significant CV=16.78% ns = not significant

Appendix Table 3.Percentage of weight loss after 5 days

TREATMENTS	REPLICATION I	II	III		TOTAL		MEAN
V_1T_0	0.20	2.00	4.30		6.50		2.17
V_1T_2	2.50	0.8	0.50		3.80		1.27
V_1T_3	0.50	1.10	0.20		1.80		0.6
V_1T_4	1.00	0.20	1.00		2.20		0.73
SUBTOTAL	4.20	4.10	6.00		14.30		4.77
V_2T_0	0.55	0.70	0.60		1.850		0.67
V_2T_1	0.3	0.50	0.05		0.85		0.28
V_2T_2	0.08	2.40	0.08		2.56		0.85
V_2T_3	1.05	2.43	0.17		3.65	11.22	
SUBTOTAL	1.98	7.00	0.90	28.91		2.97	

Two-Way Table

TREATMENT	VARIETY			
	V_1	V_2	TOTAL	MEAN
T_O-Control	6.50	0.98	7.48	1.25[a]
T_1-Mokusaku	3.80	0.85	4.65	0.78[a]
T_2-Em1	1.80	2.56	4.36	0.73[a]
T_3-Em5	2.20	3.65	5.85	1.95[a]
TOTAL	14.30	8.04	22.34	
MEAN	1.19[a]	0.67[a]		4.71

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	1.211	1.211	1.0810[ns]	3.24	5.29
Factor B	3	1.650	0.550	0.4912[ns]		
AB	3	4.290	1.430	1.2771[ns]		
ERROR	16	17.917	1.120			
TOTAL	23	38.500				

** = highly significant CV=109.42%
ns = not significant

Appendix Table 4.Percentage of weight loss after 10 days

TREATMENTS	REPLICATION			TOTAL	MEAN
	I	II	III		
V_1T_0	1.50	5.50	5.50	12.50	4.17
V_1T_2	5.50	5.00	1.00	11.50	3.83
V_1T_3	1.50	5.50	4.00	11.00	3.67
V_1T_4	4.50	2.00	3.50	10.00	3.33
SUBTOTAL	13.00	18.00	14.00	45.00	15.00
V_2T_0	2.45	2.90	2.90	8.25	2.75
V_2T_1	2.25	1.50	1.90	5.65	1.88
V_2T_2	0.18	2.60	1.20	3.68	1.33
V_2T_3	2.56	3.75	2.00	8.31	2.77
SUBTOTAL	7.44	10.75	8.00	26.19	8.73

Two-Way Table

TREATMENT	VARIETY			
	V_1	V_2	TOTAL	MEAN
T_O-Control	12.50	8.25	20.75	7.05[a]
T_1-Mokusaku	11.50	5.65	17.15	2.86[a]
T_2-Em1	11.00	3.98	14.98	2.50[a]
T_3-Em5	10.00	8.31	18.31	3.05[a]
TOTAL	45.00	26.19	70.89	
MEAN	3.75[a]	2.18[a]	3.87	

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	14.742	14.742	6.0276[ns]	3.24	5.29
Factor B	3	2.890	0.963	0.3938[ns]		
AB	3	2.661	0.887	0.3627[ns]		
ERROR	16	39.133	2.446			
TOTAL	23	59.426				

** = highly significant CV=52.72%
ns = not significant

Table 5.Percentage of weight loss after 15 days

TREATMENTS	REPLICATION	TOTAL	MEAN

	I	II	III		
V_1T_0	2.50	6.00	6.85	15.35	5.12
V_1T_2	6.00	5.50	2.50	14.00	4.67
V_1T_3	2.50	8.00	5.00	15.50	5.07
V_1T_4	4.50	2.50	5.00	12.20	4.07
SUBTOTAL	15.70	22.00	19.35	57.05	19.02
V_2T_0	2.55	3.00	5.10	10.65	3.55
V_2T_1	2.80	1.30	2.00	6.10	2.03
V_2T_2	1.98	2.65	1.65	6.28	2.09
V_2T_3	3.45	4.68	2.45	10.58	3.53
SUBTOTAL	10.78	11.63	11.20	22.96	7.66

Two-Way Table

TREATMENT	VARIETY		TOTAL	MEAN
	V_1	V_2		
T_O-Control	15.35	10.65	26.00	4.33[a]
T_1-Mokusaku	14.00	6.10	20.10	3.35[a]
T_2-Em1	15.50	6.28	21.78	3.63[a]
T_3-Em5	12.20	10.58	22.78	3.80[a]
TOTAL	57.05	33.61	90.66	
MEAN	4.75[a]	2.80[a]	3.78	

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	11.957	11.957	3.7533[ns]	3.24	5.29
Factor B	3	11.938	3.979	1.249[ns]		
AB	3	6.190	2.063	0.6477[ns]		
ERROR	16	50.971	3.186			
TOTAL	23	81.057				

** = highly significant CV=50.90%
ns = not significant

Table 6. Number of days to initial infection

TREATMENTS	REPLICATION I	II	III	TOTAL	MEAN
V_1T_0	7.00	7.00	7.00	21.00	7.00
V_1T_2	9.00	9.00	8.00	26.00	8.86
V_1T_3	7.00	7.00	10.00	24.00	8.00
V_1T_4	8.00	7.00	7.00	22.00	7.33
SUBTOTAL	31.00	30.00	32.00	93.00	31.00
V_2T_0	7.00	8.00	7.00	22.00	7.33
V_2T_1	9.00	9.00	9.00	27.00	9.00
V_2T_2	9.00	8.00	10.00	27.00	9.00
V_2T_3	8.00	8.00	8.00	24.00	8.00
SUBTOTAL	33.00	33.00	34.00	100.00	33.33

Two-Way Table

TREATMENT	VARIETY			
	V_1	V_2	TOTAL	MEAN
T_O-Control	21.00	22.00	43.00	7.17^b
T_1-Mokusaku	26.00	27.00	53.00	8.83^a
T_2-Em1	24.00	27.00	51.00	8.50^a
T_3-Em5	22.00	24.00	46.00	7.67^a
TOTAL	93.00	100.00	193.00	
MEAN	7.75^a	8.33^a		8.04

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	0.01
Factor A	1	2.042	2.042	3.2667^{ns}	3.24	5.29
Factor B	3	10.458	3.486	5.5778^{**}		
AB	3	0.458	0.153	0.2444^{ns}		
ERROR	16	10.000	0.625			
TOTAL	23	22.958				

$*^*$= highly significant CV=9.83%
ns = not significant

Table 7. Degree of Infection

TREATMENTS	REPLICATION	TOTAL	MEAN

	I	II	III		
V_1T_0	4.00	5.00	5.00	14.00	4.67
V_1T_2	3.00	4.00	5.00	11.00	3.75
V_1T_3	3.00	3.00	4.00	12.00	4.00
V_1T_4	4.00	4.00	5.00	13.00	4.33
SUBTOTAL	17.00	16.00	19.00	50.00	16.33
V_2T_0	4.00	3.00	4.00	11.00	4.00
V_2T_1	3.00	4.00	4.00	11.00	3.67
V_2T_2	4.00	5.00	5.00	14.00	4.67
V_2T_3	4.00	5.00	5.00	14.00	4.67
SUBTOTAL	15.00	17.00	18.00	51.00	17.01

Two-Way Table

TREATMENT	VARIETY		TOTAL	MEAN
	V_1	V_2		
T_O-Control	14.00	12.00	26.00	4.37[a]
T_1-Mokusaku	11.00	11.00	22.00	3.75[a]
T_2-Em1	12.00	14.00	26.00	4.33[a]
T_3-Em5	13.00	14.00	27.00	4.50[a]
TOTAL	50.00	51.00	101.00	
MEAN	4.15[a]	4.05[a]	16.83	

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	0.01
Factor A	1	0.100	0.100	0.1714[ns]	3.24	5.29
Factor B	3	3.350	0.838	1.4357[ns]		
AB	3	2.650	0.662	1.1357[ns]		
ERROR	16	17.500	0.583			
TOTAL	23	22.958				

** = highly significant CV=18.63%
ns = not significant

Table 8.Percentage of heads infected with soft rot (20 DAI)

TREATMENTS	REPLICATION	TOTAL	MEAN

	I	II	III		
V_1T_0	88.88	66.67	88.88	244.43	81.46
V_1T_2	66.67	66.67	66.67	200.01	66.67
V_1T_3	88.88	77.77	88.88	255.53	85.18
V_1T_4	77.77	88.88	77.77	244.42	81.47
SUBTOTAL	322.20	299.97	322.20	944.39	314.80
V_2T_0	88.88	77.77	88.88	255.53	85.18
V_2T_1	66.67	66.67	66.67	200.01	66.67
V_2T_2	77.77	77.77	77.77	233.31	77.77
V_2T_3	88.88	77.77	88.88	255.53	81.17
SUBTOTAL	322.20	299.98	322.20	944.38	314.80

Two-Way Table

TREATMENT	VARIETY			
	V_1	V_2	TOTAL	MEAN
T_O-Control	244.43	255.53	499.96	83.33[b]
T_1-Mokusaku	200.01	200.01	400.02	66.67[a]
T_2-Em1	255.53	233.31	488.84	83.32[a]
T_3-Em5	244.42	255.53	499.95	81.47[a]
TOTAL	944.39	944.38	1,888.77	
MEAN	78.70[a]	78.70[a]		78.78

ANOVA TABLE

SOURCE OF VARIENCE	DF	SS	MS	FC	TABULAR F 0.05	TABULAR F 0.01
Factor A	1	0.000	0.000	0.0000[ns]	3.24	5.29
Factor B	3	1171.253	390.418	9.4933**		
AB	3	123.395	41.132	1.002[ns]		
ERROR	16	658.008	41.126			
TOTAL	23	1952.657				

** = highly significant CV=8.1%
ns = not significant

CA- UR Form 4

Benguet State University
COLLEGE OF AGRICULTURE
La Trinidad, Benguet

March 21, 2012
Date

APPLICATION FOR MANUSCRIPT ORAL DEFENSE

Name: JUDY ANN V. KET-ENG

Degree (Major Field): Bachelor of Science in Agriculture (Plant Pathology)

Title of Research: POSTHARVEST MANAGEMENT OF CHINESE CABBAGE (*Brassicapekinensis)* AGAINST BACTERIAL SOFTROT (*Pectobacteriumcarotovorum*)

Endorsed: AURORA F. PINON
Adviser and Chairperson, Advisory Committee

Date and Time of Defense: March 21, 2012 at 9:00 AM

Place of Defense: Department of Plant Pathology , Room AC 107

Approved:

ANDRES A. BASALONG
Member, Advisory Committee

JOCELYN C. PEREZ
Member, Advisory Committee and Department Chairperson

RESULT OF ORAL DEFENSE

Name and Signature	Remarks (Passed/Failed)
AURORA F. PINON Adviser and Chairperson, Advisory Committee	
ANDRES A. BASALONG Member, Advisory Committee	
JOCELYN C.PEREZ Member, Advisory Committee and Department Chairperson	