**BIBLIOGRAPHY**

SAINGAN, JENNY M. APRIL 2010. Management of Clubroot Disease of Cabbage (*Plasmodiophora brassicae*) Using Alnus Compost. Benguet State University, La Trinidad Benguet.

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**ABSTRACT**

The study was conducted to determine the best amount of alnus compost as carrier of the microorganisms that can suppress clubroot of cabbage and to identify the beneficial microorganisms present in alnus compost.

It was determined that a larger amount of alnus compost can reduce clubroot disease in cabbage and can enhance the plant with good growth.Plants applied with 1part infested soil plus 20 part alnus compost and healthy soil only had the highest rating in plant height, but had the lowest rate in growth depression and clubroot severity in all the other treatments.

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## INTRODUCTION

Broadly speaking, cabbage varieties come in two groups as early and late. The early varieties mature in about 45 days. These produce small heads which do not keep well and are intended for consumption while fresh. The late cabbage matures in about 87 days and produces a larger head. Cabbage can be started indoors or sowed directly. Like all brassicaes, cabbage is cool season crops such as early and late plantings do better than those maturing in the heat of the summer.

The most common problem being encountered by the farmers on the production relates to the disease induced by several pathogenic microorganisms that cause damage to the crop. Hence, effective disease control strategies are necessary for the successful production of cabbage.

Compost is produced through the activity of aerobic (oxygen requiring) microorganisms. These microbes require oxygen, moisture, and food in order to grow and multiply. When these factors are maintained at optimal levels, the natural decomposition process is greatly accelerated. The microbes generate heat, water vapor, and carbon dioxide as these are transformed into a stable soil conditioner. Active composting is typically characterized by a high temperature phase that sanitizes the production and allows a high rate of decomposition, followed by a low temperature phase that allows the product to stabilize while still decomposing at a lower rate. Compost can be produced from many “feed stocks” (the raw organic material, such as leaves, manure or food scraps). State and federal regulations exist to ensure that only safe and environmentally beneficial compost are marketed.

Controlling the clubroot disease caused by *Plasmodiophora brassicae* is an immense problem since the causal agent is soil borne. This condition had developed a new importance in the growth of alternative control measures. Hence, biological control is one of the best solutions. Studies determined that using compost supplies nutrients needed by plants and make the macro nutrient readily available to plants over wider pH range.

This study aimed to manage clubroot of cabbage using alnus compost. Specifically, it aimed to:

1. To identify the beneficial microorganisms in the alnus compost; and

2. To determine the best amount of alnus compost as carrier of the microorganisms that can suppress clubroot of cabbage.

This study was conducted at the greenhouse of the Plant Pathology Department, Benguet State University, La Trinidad Benguet from July to September 2009.

## REVIEW OF LITERATURE

Causal Agent

Clubroot of head of cabbage is used by protozoa Plasmodiophora brassicae (Alexopolus and Mims, 1978). The causal agent is under class Plasmodiophoromycetes order Plasmodiophorales and family Plasmodiophoraceae (Sing, 1973). This fungus commonly attacks crops belonging to crucifers causing abnormality to the root system. The fungus produces resting spore inside the host cell and swims for short distance through the soil and roots of the potential host (Dickinson and Lucas, 1977). The pathogens spread from plant to plant by means of zoospores, by anything that moves soil for water containing spores, by infected transplants and so on. Its body is also plasmodium. The plasmodium gives rise to zoosporangia or to resting spores whic on germination, produce zoospores. Hansen (2000) stated that wet cool and acidic soils are favorable for the development of clubroot with optimum temperature for germination of spores and for disease development as 18˚C- 25˚C. Infection can occur, however, when temperature is as low as 12˚C or as high as 25˚C. Crucifer roots contain indoleglucosinolates, which enhance level of infection of Plasmodiophora (Voorips, 1996). (Ferriera and Boley, 1993) resting spores of P. brassicae can be disseminated through transport of infested soils by means of tools, equipments, animals and human. Water from contaminated fields is a good source of progation and spread of this disease since the pathogen can swim in wet soil.

Symptoms

The first symptoms on above ground parts vary with environmental condition and with the host. Sometimes, temporary flagging of leaves in the middle of bright days is the first sign. The symptoms occur because roots are unable to function normally. The abnormal enlargement of tap roots event underground stem are the distinctive symptoms of crucifers infested with clubroot (Sherf and Macnab, 1986). The most characteristic symptoms of clubroot have earned the nickname "finger and toes" (Partridge, 1998). It consists of swelling or abnormal enlargement of the roots. Bruel (1987) cited that almost the same first symptoms of clubroot infested crucifer crops, wilting of tops on hot days followed by partial recovery at night. Affected may be stunted.

Control

Beneficial rhizobacteria are termed by Kloepper and Schroth (1978) as "Plant Growth Promoting Rhizobacteria" (PGPR). Some PGPR strains promote plant growth directly by producing metabolites that stimulate plant growth independent of soil microflora. One of the most economical and efficient method for the control of clubroot is the development of resistant varieties. Cultural practices such as application of lime to increase pH of the soil as boron may reduce disease infection but are not sufficient to keep the plant healthy (Some et al., 1996). Rapidly growing bacteria such as *Bacillus spp.* demonstrated great effectiveness in reducing the incidence of bacterial wilt in tomato caused by *P. solanacearum* and potato in experiment situation. These antagonists colonized the long roots plants aggressively and prompt the entry of pathogen.

Alnus Compost

Alders establish symbiosis with the nitrogen-fixing Actinobacteria Frankiella alni. These bacteria convert atmospheric nitrogen into soil- soluble nitrates which can be utilized by the alder, and favorably enhances the soil fertility generally. Alders benefit other plants growing near them by taking nitrogen out of the air and depositing it in the soil in usable form. Fallen alder leaves make very rich compost and improve the soil structure, porosity, and density in effect these create a better plant root environment, increase infiltration and permeability of heavy soil, thus reducing erosion and runoff. Alder compost supplies a variety of macro and micronutrients and may control or suppress certain soil- borne plant pathogens and supplies significant quantities of organic matter. Composts improve cat ion exchange capacity (CEC) of soils and growing media, thus improving their ability to hold nutrients for plat use. It supplies beneficial microorganisms to soils and growing media. It improves and stabilizes soil pH and can bind and degrade specific pollutants. Compost can greatly enhance the physical structure of soil. In fine- textured clay, clay loam soils, the addition of compost will reduce bulk density, improve friability and porosity, and increase its gas and water permeability, thus reducing erosion. When use in sufficient quantities, the addition of compost has both an immediate and long-term positive impact on soil structure. It resists compaction in fine-textured soils and increases water holding capacity and improves soil aggregation in coarse-textured sandy soils. The soil-binding properties of compost are due to its humus content. Humus is a stable residue resulting from a high degree of matter decomposition. In addition, Follet (1981) emphasized that organic residues on the surface of the soil protect against raindrop, splash erosion, reduce the extreme of surface temperature when

organic residues are composted. They supply some essential nutrients needed by the plants, and make the macro nutrient available to plants over wider pH range.

High compost rates increased the soil total microbial population and number of fungal species. Microbial populations were larger in the organic conversion area than the conventional area. Soil in the organic conversion area supported approximately twice the number and a wider range of fungl species than cultivated area. Species abundance and richness of zygomycetes fungi nd occurrence of fungi potentially antagonistic conversion area (Sivapalan and Morgan, 1983).

Biological Control

Resident antagonists are natural inhabitants of soil that found on the rhizosphere. Introduced are those cultured with special condition and applied to sites where needed like the soil and seeds, they may also be sprayed on leaves or on any parts organ of the plants. (Mukerji and Garg. 1988). Isolated antagonists from soil namely *Bacillus spp.* shoed the antagonistic capacity on potato stem cuttings, whole piece and sliced tuber. *Bacillus sp.* is said to be safety as agent in controlling disease of potato. (Na-oy, 1989). Rapidly growing bacteria such as *Bacillus sp.* demonstrated great and efficient in reducing the incidence of bacterial wilt in tomato caused by *P. solanacearum* and potato in experimental situation. These antagonists colonized the long roots of plants aggressively and prompt the entry of pathogen. In separate laboratory and greenhouse experiments, Molina (1985) stated that *Penicillium sp,* could inhibit the growth of the number of soil fungal pathogens such as *R. solani*, *R. rolfsii*, *F. oxyporum* and *Pseudomonas*. These cultural filtrates prove more effective against the pathogens.

## MATERIALS AND METHODS

A.Greenhouse Activity

Seeds of rareball (RB) variety of cabbage were sown and germinated for one month. Plastic pots were filled with 1 kg of mountain soil then were mixed with infested soil of clubroot. After five days alnus compost was mixed with appropriate label as shown in the production of inucula.

1. Planting

One week after the application of compost, cabbage seedlings were transplanted. Proper cultural practices were provided to ensure good growth.

2. Production of Inocula

The treatments were replicated four times per treatment using the complete randomized design (CRD). The following are the different treatments:

$T_{1=}$ 1 infested soil + 1 part of alnus compost (1:1)

$T_{2=}$ 1 part of infested soil + 5 parts of alnus compost (1:5)

$T_{3=}$ 1 part of infested soil + 10 parts of alnus compost (1:10)

$T_{4=}$ 1 part of infested soil + 20 parts of alnus compost (1:20)

$T_{5=}$ infested soil only

$T_{6=}$ infested soil + chicken dung

$T_{7=}$ fungicide

$T_{8=}$ healthy soil only

B. Laboratory Activity

To determine the microorganisms present in the alnus compost, leaves were collected and pulverized into fine particles. About 10 grams were added to 100 ml of sterilized distilled water and allowed to stand for 1 minute. Different dilutions were prepared by withdrawing 1 ml of the suspension and added in the test tube containing 9 ml sterilized distilled water to come up with dilution of 1:10, 1 ml of each dilution was dispensed in to the prepared media, nutrient agar (NA) and potato dextrose agar (PDA). After 24 -48 hours, fungal growths that appeared on the media were re-isolated. Identification of fungal microorganisms was identified through their natural characteristics.

Data Gathered

1. Plant height. Plant height was measured at 30, 40, and 50 days after transplanting (DAT).

2. Growth depression. All plants were evaluated on wilting and stunting expressed as growth depression, and plant death. Rating use was based on Tad-awan (1986).

| Scale | Description |
|---|---|
| 1 | Normal aerial growth |
| 2 | Slight growth of depression |
| 3 | Moderate growth depression |
| 4 | Severe plant inhibition |
| 5 | Plant death |

3. Clubroot Severity Index.

All plants were uprooted to evaluate the severity of clubbing symptoms using the rating of Tad-awan (1986).

| Rating | Description |
|---|---|
| 1 | Normal root |
| 2 | Minor lateral clubbing |
| 3 | Major lateral clubbing |
| 4 | Moderate clubbing on taproot |
| 5 | Severe clubbing on taproot |
| 6 | Root decaying due to advance infestation |

## RESULTS AND DISCUSSIONS

Effect of Alnus Compost
in Plant Height

Plant height is shown in Table 1 at 30 (days after transplanting) DAT all treatments did not show any signs of stunting and wilting. All plants were normal as of the height. Treatment 4 which 1 part infested soil plus 20 parts of alnus compost together with treatment 8 (healthy soil only) showed good growth among all the treatments. On the 40 DAT, Treatments showed gradual stunting and wilting. Treatment 5 (infested soil only) formed minor clubbing. At 50 DAT, Treatment 4 and 8 (healthy soil only) showed minor stunting while Treatment 5 (infested soil only) had major lateral clubbing.

Table 1. Height at 30 DAT, 40 DAT and 50 DAT

| TREATMENTS | HEIGHT (cm) 30 DAT | 40 DAT | 50 DAT |
|---|---|---|---|
| $T_1$ (1:1) | 10.00[a] | 11.00[a] | 11.93[a] |
| $T_2$ (1:5) | 10.07[a] | 10.65[a] | 12.17[a] |
| $T_3$ (1:10) | 10.07[a] | 11.03[a] | 12.01[a] |
| $T_4$ (1:20) | 10.09[a] | 11.09[a] | 12.93[a] |
| $T_5$ infested soil only | 10.04[a] | 10.85[a] | 10.05[a] |
| $T_6$ infested soil + chicken dung | 10.06[a] | 10.85[a] | 11.43[a] |
| $T_7$ fungicide | 10.05[a] | 11.02[a] | 11.33[b] |
| $T_8$ healthy soil only | 11.05[a] | 11.00[a] | 12.00[b] |

Means with common notation (letter) are not significantly different at 1 % level of significance (DMRT)

Statistical analysis shows that plant treated with 1 part soil and 20 part of alnus compost obtain the lowest mean (1) and also the healthy soil only, treatment 8 (1). Plants without treatment, Treatment 5 have the highest mean (3) over all treatments.

Effect of Alnus Compost
in Growth Depression

All treatments did not show any growth depression on the week of the rating, at 30 DAT as shown in Table 2. Plants on 40 DAT showed moderate growth depression. Treatment 5 (infested soil only), Treatment 6 chicken dung and Treatment 7, fungicide, first showed wilting and stunting. This observation was validated with the statement of Brooks and Hallstead (1980) that plants become stunted particularly if the plants are infected at the seedling stage, although other plants may show discolored. Other plant treated with alnus compost shows only slight aerial growth and Treatment 4 and 8 incurred normal growth depression. Plants at 50 DAT mostly obtained moderate growth depression. Plants with no treatment has the rate of severe inhibition that some lead to death. Plants treated with1:20 together with Treatment 8 (healthy soil only) had the least growth depression.

Table 2. Growth Depression at 30 DAT, 40 DAT and 50 DAT

| TREATMENTS | GROWTH DEPRESSION | | |
|---|---|---|---|
| | 30 DAT | 40 DAT | 50 DAT |
| $T_1$ (1:1) | 1.00[a] | 2.00[a] | 3.00[b] |
| $T_2$ (1:5) | 1.00[a] | 2.00[a] | 3.00[b] |
| $T_3$ (1:10) | 1.00[a] | 1.05[a] | 2.33[a] |
| $T_4$ (1:20) | 1.00[a] | 1.00[a] | 1.33[a] |
| $T_5$ infested soil only | 2.00[a] | 3.00[a] | 4.00[a] |
| $T_6$ infested soil + chicken dung | 1.05[a] | 2.05[a] | 3.00[a] |
| $T_7$ fungicide | 2.00[a] | 3.00[a] | 3.00[b] |
| $T_8$ healthy soil only | 1.00[a] | 1.00[a] | 1.00 |

Means with common (letter) are not significantly different at 1% level of significance (DMRT)

Statistical analysis shows in Table 2 that the highest mean (3) is the infested soil only, and followed by Treatment 6 and 7. Plants treated with high amount of alnus compost together with healthy soil only Treatment 8 obtained the least mean.

Effect of Alnus Compost
in Clubroot

Plants treated with least alnus compost had effect in clubroot. Plants treated with 1 part infested soil + 20 parts of alnus compost had an efficacy in clubroot also with growth and the quality of the plant. Treatments treated with chicken dung and fungicide is no effect in clubroot which shows that it is inefficient to suppress clubroot. Healthy soil only was no indication of high infection of clubroot.

In Table 3 it shows that during the 30 DAT, there were no signs of clubbing. During the 50 DAT, it appeared that almost plant shows symptoms of clubbing.

Statistical analysis shows that in Table 3 shows that plants treated with high amount of alnus compost has the lowest mean (1) also with plants treated healthy soil only(1). Treatment 5 (infested soil only) has the highest mean (3.67), also with the treatment 6 (3.33) followed by treatment7 (3.67).

Table 3. Clubroot Severity at 30 DAT, 40 DAT and 50 DAT

| TREATMENTS | CLUBROOT SEVERITY | | |
|---|---|---|---|
| | 30 DAT | 40 DAT | 50 DAT |
| T1 (1:1) | 1.05[a] | 2.00[a] | 2.67[a] |
| $T_2$ (1:5) | 1.05[a] | 2.00[a] | 2.33[a] |
| $T_3$ (1:10) | 1.00[a] | 2.00[a] | 2.33[a] |
| $T_4$ (1:20) | 1.00[a] | 1.05[a] | 1.33[a] |
| $T_5$ infested soil only | 3.00[a] | 3.05[a] | 3.67[b] |
| $T_6$ infested soil + chicken dung | 3.00[a] | 2.05[a] | 3.33[a] |
| $T_7$ fungicide | 2.00[a] | 3.00[ab] | 3.67[c] |
| $T_8$ healthy soil only | 1.00[a] | 1.00[ab] | 1.33[c] |

Means with common notation (letter) are not significantly different at 1 % level of significance. (DMRT)

Identification of Biocontrol Agents

Cultural Characteristics suspected BCA's isolated in culture media includes. *Bacillus sp.* is identified to have chromogenesis of milky or white in NA. It formed almost circular. It has smooth surface and elevation (Fig 1). Using (PDA), *Penicillium sp.* was isolated which appeared green and sometimes turning gray (Fig 2). Like some organism *Penicillium* is bearing individually constricted conidiophores. The conidiophores are the main route of dispersal. It is a fast growing organism when cultured and appeared to be powdery and mostly it grows circular on the surface of the media. *Curvularia sp.* appeared gray to black in color with fluffy growth on the colony surface (Fig 3).

Table 4. Isolated organism from alnus leaves compost

| ORGANISM | CHARACTERISTICS ON CULTURE MEDIA |
|---|---|
| Fungi | |
| *Penicillin sp* | green or gray |
| *Curvularia spp.* | gray to black |
| Bacteria | |
| *Bacillus sp.* | milky to white |

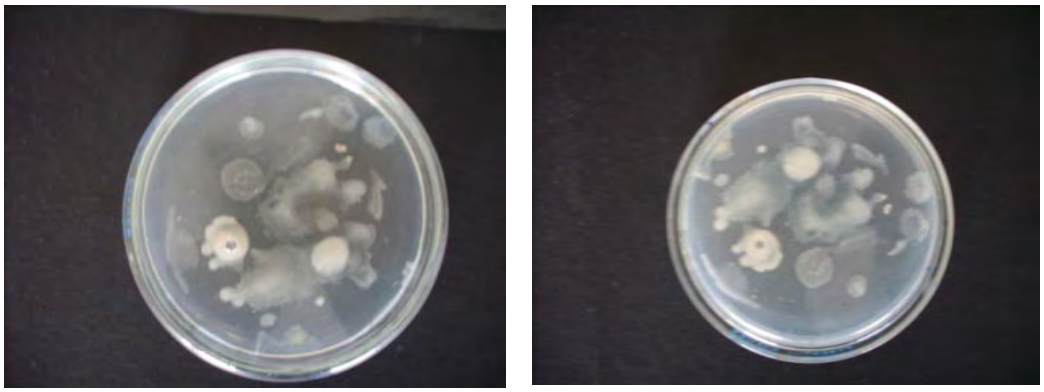

Figure 1. *Bacillus sp.* isolated in NA

Figure 2. *Penicillum sp.* isolated in PDA

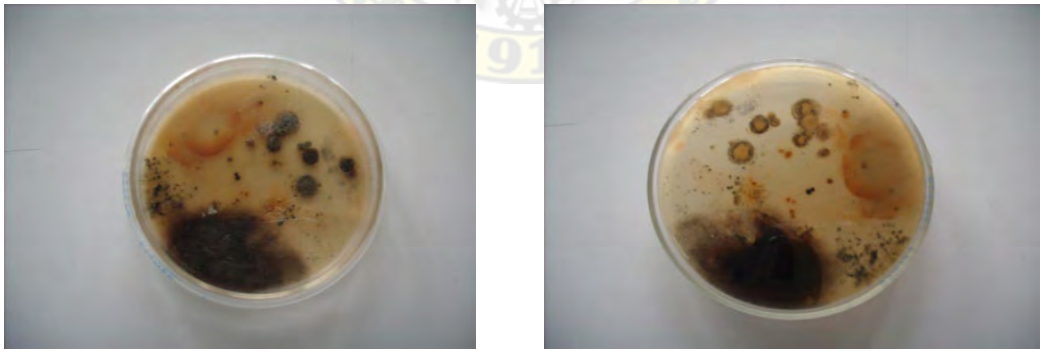

Figure 3. *Curvularia sp.* isolated in PDA

Microscopic Characteristics. *Bacillus sp.* appeared rod in shaped cells, straight with rounded ends occurring in short or single chains. When stained, it appeared to be Gram positive (Figure 4). *Curvularia sp.* is one of the most organisms that bear conidia. Conidia of *Curvularia* sometimes differ in sizes and in shape (Figure 5). It easily distinguish from other species since the conidia are non- distoseptate, meaning, (from the edge to edge of the conidial wall). *Penicillium sp.* is bearing individually constricted conidiophores. The condiophores are the main dispersal route of the fungi and it is often green (Figure 6).

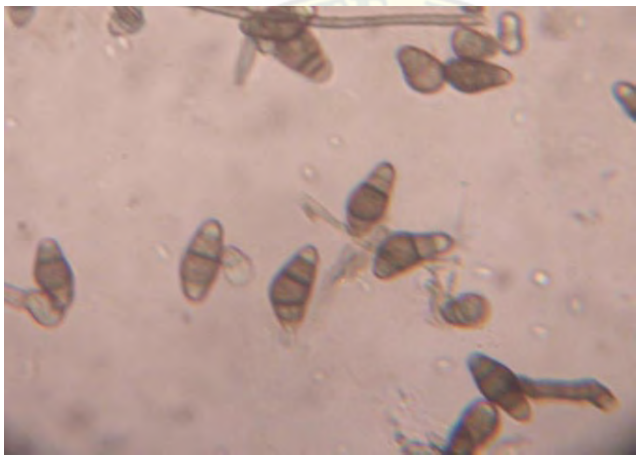

Figure 5. Conidia of *Culvularia sp* (400×)

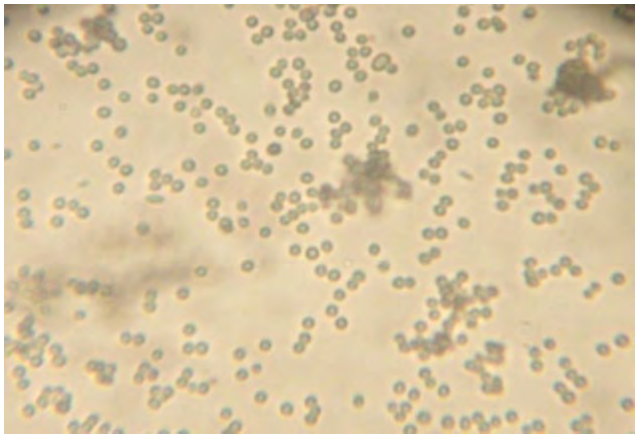

Figure 6. Conidia of *Penicillium sp.* (400×)

Plant Height

Figure 7 shows at 30 DAT, all plants were normal. The 40 DAT only Treatment 5 (infected soil only) showed wilting. Plants treated with alnus compost, chicken dung and fungicide had good leaves and fast growth. At 50 DAT, it was observed that plants infected soil only had the slowest growth among all plants. Plants treated with greater amount of alnus compost had the faster growth together with plants treated with healthy soil only.

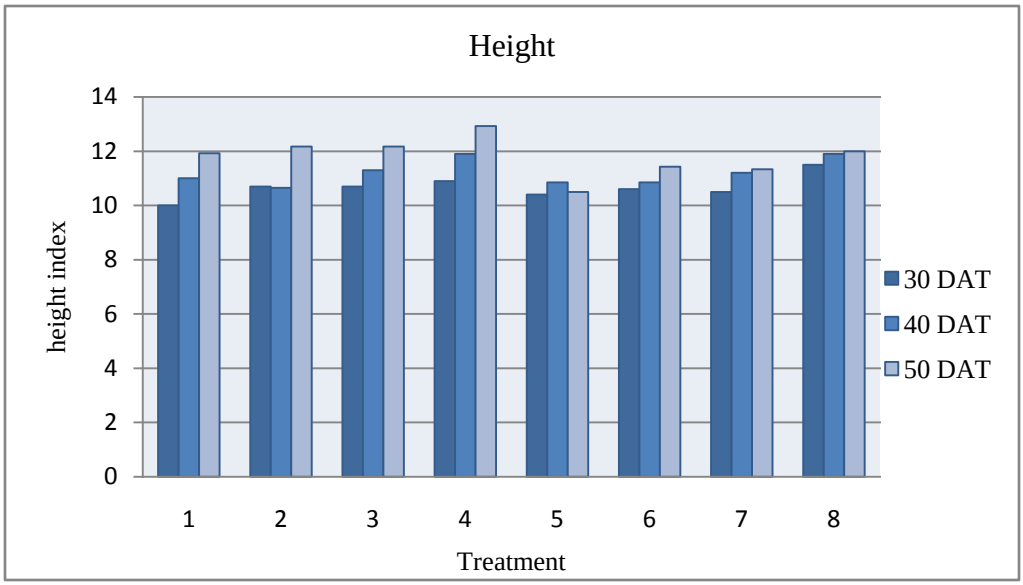


Figure 7. Variation of plant height in cm from 30 DAT, 40 DAT and 50 DAT

Growth Depression

Figure 8 shows that 30 DAT all plants had normal above ground growth. At 40 DAT, plants without treatment showed moderate growth depression. Plants treated with 1:20 treatments with healthy soil only showed normal above ground growth. Treatments treated with the least amount of alnus compost, together with the treatments treated with fungicide and chicken dung showed slight growth depression. At 50 DAT plants increased in growth depression. Plants treated with high amount of alnus compost and treatments with healthy soil only obtained the lowest growth depression and treatments treated with infected soil only obtained the highest growth depression.

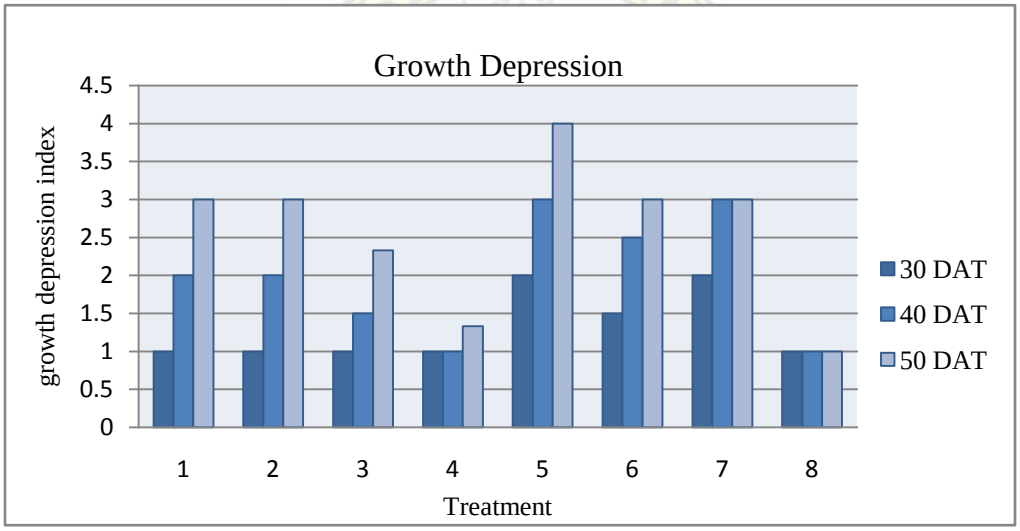


Figure 8. Variation of growth depression from 30 DAT, 40 DAT and 50 DAT

Clubroot Severity

Treatment 5 had the highest case of clubroot severity followed by Treatment 7 (fungicide), followed by Treatment 6 (chicken dung). Treatments treated with the least amount of alnus compost were somehow infected with major lateral clubroot. While Treatment 4, with the greater amount of alnus compost was infected with minor lateral clubbing together with Treatment 8, (healthy soil only) as shown in Figure 9.

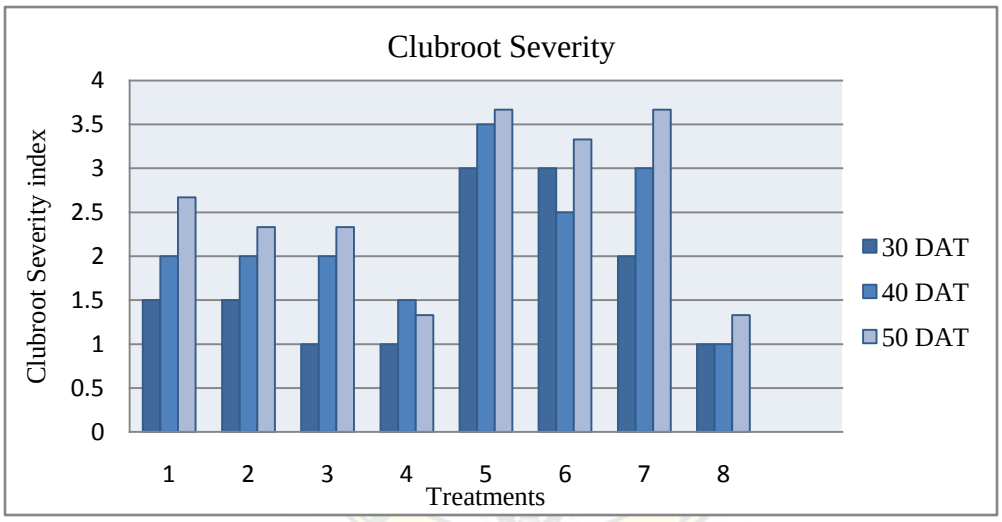


Figure 9. Variation of clubroot severity from 30 DAT, 40 DAT and 50 DAT

Plants were uprooted every ten days interval. Every plant was measured as for height, evaluated as for growth depression and clubroot severity using the rating scale of Tad-awan (1986). Figures 10 to 17 shows differences of the treatments after the 30 DAT to 50 DAT wherein, during 30 DAT (left) there was no clubbing of roots, whereas 50 DAT ( right) showed minor and major clubbing as shown below.

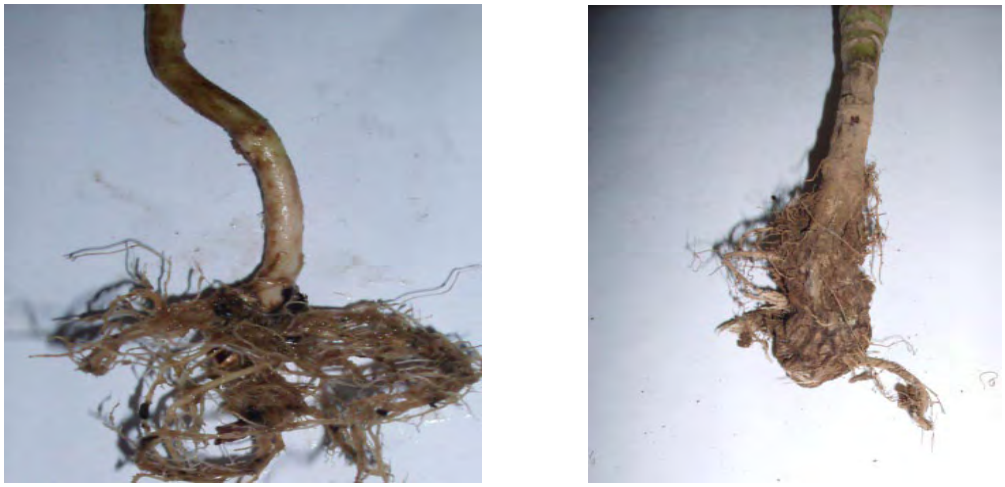

Figure 10. Treatment 1 (1:1) had normal roots 30 DAT to clubbing 50 DAT

Figure 11. Treatment 2 (1:5) had normal roots 30 DAT to clubbing 50 DAT

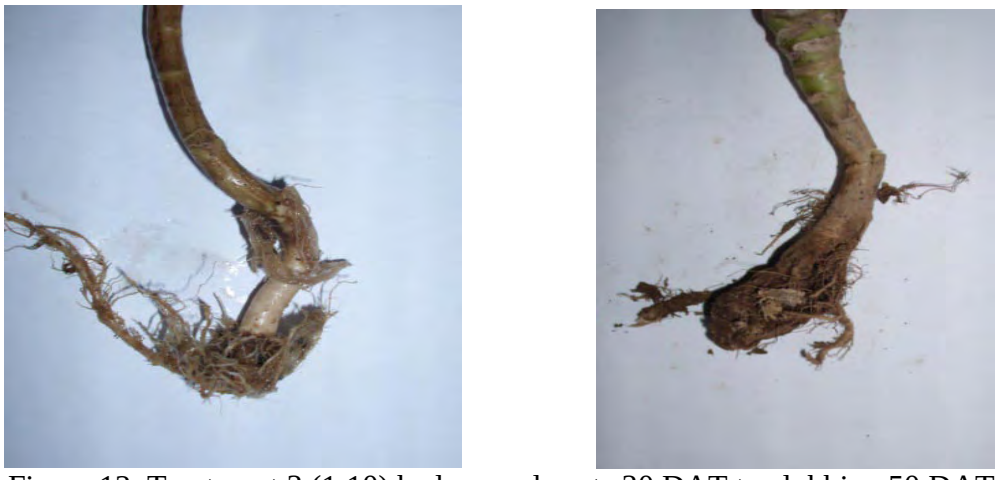

Figure 12. Treatment 3 (1:10) had normal roots 30 DAT to clubbing 50 DAT

Figure 13. Treatment 4 (1:20) had normal roots 30 DAT to clubbing 50 DAT

Figure 14. Treatment 5 (infested soil only) had normal roots 30 DAT to clubbing 50 DAT

Figure 15. Treatment 6 (chicken dung) had normal roots 30 DAT to clubbing 50 DAT

Figure 16. Treatment 7 (fungicide) had normal roots 30 DAT to clubbing 50 DAT

Figure 17. Treatment 8 (healthy soil only) had normal roots 30 DAT to clubbing 50 DAT

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS


Summary

The experiment was conducted at the Department of Plant Pathology Greenhouse, Benguet State University, La Trinidad Benguet from July to September 2009 to determine the efficacy of alnus compost against clubroot of cabbage variety (Rareball) and to find out the best amount of alnus compost that can be applied and to identify the microorganism that can be present in the said compost.

Study showed that Treatment 4 (1 part of infested soil + 20 parts of alnus compost) and Treatment 8 (healthy soil only) had the highest rating among all treatments. Plants treated with least alnus compost were infected with clubroot. In the final rating Treatment 5 having the infested soil obtained lowest rating among all treatments. Plants treated with high amount of alnus compost have good growth. Microorganisms that were identified were; *Penicillium sp*., *Curvularia sp*. and *Bacillus sp*.


Conclusions

1. Alnus compost enhances and promotes good growth in cabbage;

2. Applying 1 part infested soil+ 20 parts of alnus compost in plants infected by clubroot has minimal infection compared to less amount of alnus compost;

3. *Bacillus sp.* and *Penicillium sp*. are good antagonist that can suppress *Plasmodiophora brassicae*. However *Curvularia sp*. is still not known for what it might treat.

Recommendations

1. Alnus compost can be used to enhance the soil for good production of plants.

2. Alnus compost when treated with 1 part infested soil+ 20 parts can promote good growth in cabbage.

3. To improve plant performance, it is good to apply alnus compost in fields or in pots before planting or transplanting.

4. The result of this greenhouse experiment is recommended for further identification in the field.

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**APPENDICES**

Appendix Table 1.Plant height (cm) at 30 DAT

| TREATMENTS | REPLICATION I | II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 10.00 | 10.00 | 20.00 | 10.00 |
| T2 | 10.06 | 10.08 | 21.04 | 10.07 |
| T3 | 10.08 | 10.08 | 21.08 | 10.07 |
| T4 | 11.03 | 11.00 | 22.08 | 10.09 |
| T5 | 10.04 | 10.04 | 20.08 | 10.04 |
| T6 | 10.03 | 10.08 | 21.01 | 10.06 |
| T7 | 10.05 | 10.05 | 21.00 | 10.05 |
| T8 | 11.03 | 11.00 | 21.00 | 11.05 |
| TOTAL | | | 171.3 | 21.4125 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | FO.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatment | 7 | 0.1544 | 0.4506 | 8.2836 | 6.18 | 3.50 |
| Error | 8 | 0.23 | 0 | | | |
| Total | 15 | 0.8394 | 0.0288 | | | |

*not significant CV=1%

Appendix Table 2. Plant heights in (cm) at 40 DAT

| TREATMENTS | REPLICATION I | REPLICATION II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 11.00 | 11.00 | 22.00 | 11.00 |
| T2 | 10.03 | 11.00 | 21.03 | 10.65 |
| T3 | 11.02 | 11.04 | 22.06 | 11.03 |
| T4 | 12.00 | 11.08 | 23.08 | 11.09 |
| T5 | 10.07 | 11.00 | 21.07 | 10.85 |
| T6 | 10.07 | 11.00 | 21.07 | 10.85 |
| T7 | 11.04 | 11.00 | 22.04 | 11.02 |
| T8 | 11.08 | 12.00 | 23.08 | 11.09 |
| TOTAL | | | 179.3 | 11.20625 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatment | 7 | 0.1544 | 0.4506 | 8.2836 | 6.18 | 3.50 |
| Error | 8 | 0.475 | 0.0594 | | | |
| TOTAL | 15 | 3.6294 | | | | |

**highly significant CV=2.1749%

Appendix Table 3. Plant height (cm) at 50 DAT

| TREATMENTS | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| T1 | 12.00 | 11.08 | 12.00 | 35.08 | 11.93 |
| T2 | 12.00 | 12.00 | 12.05 | 36.05 | 12.17 |
| T3 | 12.00 | 12.05 | 12.00 | 36.05 | 12.17 |
| T4 | 13.00 | 13.05 | 12.03 | 38.08 | 12.93 |
| T5 | 10.06 | 10.07 | 10.02 | 31.05 | 10.05 |
| T6 | 11.02 | 11.05 | 11.06 | 34.03 | 11.43 |
| T7 | 11.00 | 11.03 | 11.00 | 33.03 | 11.33 |
| T8 | 12.00 | 12.05 | 11.05 | 36.00 | 12.00 |
| TOTAL | | | | 282.4 | 11.77 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 12.1910 | 1.742 | 7.69 | 6.18 | 3.50 |
| Error | 8 | 1.1813 | 0.2267 | | | |
| TOTAL | 15 | 14.0133 | | | | |

**highly significant CV= 4-05%

Appendix Table 4. Growth depression at 30 DAT

| TREATMENTS | REPLICATION I | REPLICATION II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 1.00 | 1.00 | 2.00 | 1.00 |
| T2 | 1.00 | 1.00 | 2.00 | 1.00 |
| T3 | 1.00 | 1.00 | 2.00 | 1.00 |
| T4 | 1.00 | 1.00 | 2.00 | 1.00 |
| T5 | 2.00 | 2.00 | 4.00 | 2.00 |
| T6 | 2.00 | 1.00 | 3.00 | 1.05 |
| T7 | 2.00 | 2.00 | 4.00 | 2.00 |
| T8 | 1.00 | 1.00 | 2.00 | 1.00 |
| TOTAL | | | 21 | 1.3 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 2.9375 | 0.4196 | 6.71** | 6.18 | 3.50 |
| Error | 8 | 0.5 | 0.0625 | | | |
| TOTAL | 15 | 3.4375 | | | | |

not significant CV= 19.05%

Appendix Table 5. Growth Depression at 40 DAT

| TREATMENTS | REPLICATION I | II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 2.00 | 2.00 | 4.00 | 2.00 |
| T2 | 2.00 | 2.00 | 3.00 | 2.00 |
| T3 | 1.00 | 2.00 | 2.00 | 1.05 |
| T4 | 1.00 | 1.00 | 2.00 | 1.00 |
| T5 | 3.00 | 3.00 | 6.00 | 3.00 |
| T6 | 3.00 | 2.00 | 5.00 | 2.05 |
| T7 | 3.00 | 3.00 | 6.00 | 3.00 |
| T8 | 1.00 | 1.00 | 1.00 | 1.00 |
| TOTAL | | | 32 | 2 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatment | 7 | 9 | 1.2858 | 10.2856 | 6.18 | 3.50 |
| Error | 8 | 1 | 0.125 | | | |
| TOTAL | 15 | 10 | | | | |

**highly significant CV= 17.68%

Appendix Table 6. Growth depression at 50 DAT

| TREATMENTS | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| T1 | 3.00 | 3.00 | 3.00 | 9.00 | 3.00 |
| T2 | 3.00 | 3.00 | 3.00 | 9.00 | 3.00 |
| T3 | 2.00 | 2.00 | 3.00 | 7.00 | 2.33 |
| T4 | 1.00 | 2.00 | 1.00 | 4.00 | 1.33 |
| T5 | 4.00 | 4.00 | 4.00 | 12.00 | 4.00 |
| T6 | 3.00 | 3.00 | 3.00 | 9.00 | 3.00 |
| T7 | 3.00 | 3.00 | 3.00 | 9.00 | 3.00 |
| T8 | 1.00 | 1.00 | 1.00 | 3.00 | 1.00 |
| TOTAL | | | | 62 | 2.58 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 20.5 | 2.9286 | 17.5720** | 6.18 | 3.50 |
| Error | 8 | 1.333 | 0.1667 | | | |
| TOTAL | 15 | 2.8333 | | | | |

**highly significant CV= 15.81%

Appendix Table 7. Clubroot severity at 30 DAT

| TREATMENTS | REPLICATION I | II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 1.00 | 2.00 | 3.00 | 1.05 |
| T2 | 2.00 | 1.00 | 3.00 | 1.05 |
| T3 | 1.00 | 1.00 | 2.00 | 1.00 |
| T4 | 1.00 | 1.00 | 2.00 | 1.00 |
| T5 | 3.00 | 3.00 | 6.00 | 3.00 |
| T6 | 3.00 | 3.00 | 6.00 | 3.00 |
| T7 | 2.00 | 2.00 | 4.00 | 2.00 |
| T8 | 1.00 | 1.00 | 2.00 | 1.00 |
| TOTAL | | | 28 | 1.75 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 10 | 1.4286 | 11.4288** | 6.18 | 3.50 |
| Error | 8 | 1 | 0.125 | | | |
| TOTAL | 15 | 11 | | | | |

not significant CV= 20.20%

Appendix Table 8. Clubroot severity at 40 DAT

| TREATMENTS | REPLICATION I | REPLICATION II | TOTAL | MEAN |
|---|---|---|---|---|
| T1 | 2.00 | 2.00 | 4.00 | 2.00 |
| T2 | 2.00 | 2.00 | 4.00 | 2.00 |
| T3 | 2.00 | 2.00 | 4.00 | 2.00 |
| T4 | 1.00 | 2.00 | 3.00 | 1.05 |
| T5 | 4.00 | 3.00 | 7.00 | 3.05 |
| T6 | 3.00 | 2.00 | 5.00 | 2.05 |
| T7 | 3.00 | 3.00 | 6.00 | 3.00 |
| T8 | 1.00 | 1.00 | 2.00 | 1.00 |
| TOTAL | | | 35 | 2.19 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 8.9375 | 1.2768 | 6.8095** | 6.18 | 3.50 |
| Error | 8 | 1.5 | 0.1875 | | | |
| TOTAL | 15 | 10.4375 | | | | |

*highly significant CV= 19.79%

Appendix Table 9. Clubroot severity at 50 DAT

| TREATMENTS | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| T1 | 3.00 | 3.00 | 2.00 | 8.00 | 2.67 |
| T2 | 2.00 | 2.00 | 3.00 | 7.00 | 2.33 |
| T3 | 2.00 | 3.00 | 2.00 | 7.00 | 2.33 |
| T4 | 1.00 | 2.00 | 1.00 | 4.00 | 1.33 |
| T5 | 4.00 | 4.00 | 3.00 | 11.00 | 3.67 |
| T6 | 4.00 | 3.00 | 3.00 | 10.00 | 3.33 |
| T7 | 4.00 | 4.00 | 3.00 | 11.00 | 3.67 |
| T8 | 1.00 | 1.00 | 2.00 | 4.00 | 1.33 |
| TOTAL | | | | 62 | 2.58 |

ANALYSIS OF VARIANCE

| SV | DF | SS | MS | FC | F0.01 | F0.05 |
|---|---|---|---|---|---|---|
| Treatments | 7 | 18.5 | 2.6429 | 3.9642* | 6.18 | 3.50 |
| Error | 8 | 5.3334 | 0.6067 | | | |
| TOTAL | 15 | 23.8333 | | | | |

*highly significant CV= 31.61%