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# Efficacy of Botanical Pesticides in Controlling Insect Pests of Three Pigeon Pea Varieties

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## ABSTRACT

Pigeon Pea (*Cajanus cajan*) is a high-value crop with its nutritional and medicinal properties that could augment food security. Pigeon pea is prone to pests attack that could affect its yield, thus, this study is conceived. This study aimed to evaluate the effect of botanical pesticides in controlling insect pests of three pigeon pea varieties. Specifically, it sought to: 1) determine which of the botanical pesticides can effectively control insect pests of pigeon pea; 2) find out which among the pigeon pea varieties has the least damage by insect pests; and 3) identify and recommend the best-botanical pesticides to control insect pests of pigeon peas. The experiment was laid out in Factorial Randomized Complete Block Design. Data gathered were analyzed using the Analysis of Variance. Significant differences among treatment means were analyzed using the Duncan Multiple Range Test. The results implied that the botanical extract applied to the pigeon pea plants exhibited a significant effect in terms of controlling the pests. The results of the study conclude that the application of botanical extracts is comparably effective in controlling pests of pigeon pea. The study recommends that $B_1$ (Neem Leaf Extract), $B_2$ (Yellow Ginger Extract) and $B_3$ (Hot Pepper Extract) can be used to control insect pests of pigeon peas; $V_2$ (ICPL 87119) is recommended for production due to its resistance to pests.

***Keywords*** **–** Science, botanical pesticide, pigeon pea varieties, experimental design, Philippines

## INTRODUCTION

Pigeon Pea (*Cajanus cajan*) is one of the most-versatile crops because of its varied uses. It is a staple food that provides good protein either fresh peas or dried peas like any other beans or lentils. It is thought to have originated in India, where it is still widely grown as a food crop and plays a significant role in achieving food and nutritional security. Dhal is made from pigeon pea. The peas can also be sprouted to make them even more nutritious and can be made into flour. Pigeon pea leaves, flowers, seeds and pods are all nutritious animal fodder (Tropical Permaculture, 2007).

The plant is also used extensively as a cover crop, green crop and intercrop in many sustainable farm systems in the tropics and subtropics especially in the semi-arid regions. It also requires low farm inputs and drought tolerant. In Abra, pigeon production has not been given priority. The crop has been grown as backyard hedge from which pods are harvested for home consumption using traditional varieties. The supply of pigeon pea in the locality is often limited due to lack of appropriate technologies in the cultivation of improved varieties and longer production cycles of traditional varieties. Abra has a great potential for pigeon pea production considering its resources as vast marginal uplands and semi-arid climatic condition.

To attain food security and improved nutrition of increasing population, production of pigeon pea becomes urgent being an important source of proteins and vitamins. Hence, this study is conceived.

Pigeon peas (*Cajanus cajan)* originated in India and appeared about 2000 BC in West Africa, which is considered their second major centre of origin. Pigeon peas are currently wide spread throughout the tropics and subtropics. They are cultivated in India, Malaysia, Indonesia, the Philippines, Caribbean, East and West Africa (Agriculture, Forestry and Fisheries, Republic of South Africa, 2009).

Pigeon peas grow well in temperatures between 18 and 29 °C. The plants are sensitive to waterlogging and frost. The crop grows well in all types of soils, varying from sandy to heavy loams, with well-drained, medium heavy loams being best. It requires a pH ranging from 5.0 to 7.0. It is one of the most drought tolerant and frost intolerant legume crops, with a wide range of rainfall intolerance but prefers optimal rainfall ranging between 400 and 750 mm per annum. Pigeon

pea prefers moist conditions for the first two growing months, drier conditions during flowering and harvesting.

Pigeon pea is best established by direct seeding in a well-prepared field. Seed inoculation is not usually needed but if inoculating, a cowpea group strain of *Rhizobium* can be used. It thrives best in a seed bed prepared by deep tillage to reduce weeds. Primary tillage assists the soil to dry makes earlier seeding possible. Seeds can be sown from 2.5 to 10 cm deep by hand dibbling. Seeds can be broadcasted at a seed rate of 45 to 67 kg/ha, or at least a maize planter can be used for seeding.

A plant shows little response to nitrogen fertilizers and usually to phosphorus and requires enough calcium, potash and magnesium. The plant has to be inoculated with *Rhizobium* to enhance nitrogen fixation. Pigeon pea can be used as a green manure crop.

It is one of the most drought-tolerant legume crops, with a wide rainfall tolerance. In dry areas with less than 400 mm annual rainfall, water can be supplemented by irrigation for the first two growing months, and during flowering to harvesting the irrigation should cease to reduce damage by pests and diseases.

Pigeon pea is very sensitive to weed competition in the first 45 to 60 days of growth because of its slow-initial growth rate. Effective weed control at the early growth stages of the crop is one of the most-important factors contributing to high yields, especially during the first four to eight weeks.

Insect pests and diseases have a negative impact on pigeon pea productivity and poor quality seed. Pests and diseases reduce the plant stand however; these can be controlled by the use of pest resistant cultivars, crop rotations, and weed removal, inoculation with cow pea group strain of *Rhizobium* and intercropping with cereals.

According to Calleja (2010), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is encouraging Filipino farmers to produce more pigeon pea (*Cajanus cajan*) as export commodity to India.

CalIeja further stated that, according to ICRISAT Executive Director Dr. William Dar, it is interesting to note that while pigeon pea is considered a minor crop in the Philippines, usually grown in the backyards or some insignificant portions of the farm, it is consumed in big volumes in India that although largely produced in that country, it still imports three million tons of the commodity per year. Dar believes that domestic production of pigeon pea called "super crop" for dry-land agriculture should be given due attention. It is a protein-rich human

food and excellent animal feed aside from its usefulness in increasing soil fertility, in preventing soil erosion and in suppressing weeds in upland farms. Pigeon pea is one crop that will thrive even in areas where the rainy season is short and dry periods are long, like many parts in the Philippines. It will grow even in hilly areas where many other crops fail. Pigeon pea is drought-resistant because it is deep-rooted. Being a legume, it can fix nitrogen from the air into the soil, hence enhancing soil fertility. It also produces green manure to add nutrients and organic matter to the soil. The pods and leaves of the pigeon pea are consumed as vegetables. Pigeon pea greens, as well as the peas themselves, are used as feeds to animals. As a medicinal crop, the Hamdard Publication 'Dehati Mualij' from New Delhi, India says it is useful as a remedy to the swelling of internal organs like the stomach, liver, and intestines. Pigeon pea contains high levels of Vitamin B, protein, and, amino acids such as methionine, lysine, and tryptophan, and makes for a well-balanced human food, it said.

There were several benefits that could be derived from pigeon pea production among them were the following: it can survive in poor soil conditions; tolerant of dry weather; nutritious and high-protein pulse crop; leaves can be used for animal feed; the fast-growing plants make good shade for other crops, e. g. vegetables, herbs, vanilla perennial for up to five years; woody parts can be used for firewood; water and nutrients from deep in the soil can be caught by its deep taproot; plants can be used along contour barriers for erosion control; and helps in agro-ecology, performance of pigeon pea as an intercrop is remarkable and even after the harvesting of the intercrop it continues protecting the soil.

Pagluanan (2010) claimed that ICPL 7035, a short duration variety may be planted in upland areas in Abra because this variety produced favorable yield with an average of 791.88 kgs. of dry seeds per hectare. Yields of up to 3 t/ha have been recorded under very favorable seasonal conditions. Yields under normal conditions should be between about 0.5 and 2 t/ha.

Pigeon peas are attacked by several insect pests in the field. One of the common insect pest is Heliothis. Heliothis is the major pest of pigeon pea and can completely devastate a crop if not correctly managed. The pest attacks the plants during flowering and pod development stage. The eggs are laid in and around flowers.

Local producers preferred quality products to obtain high yield. However, several problems arise in producing high yield and quality products. The attack of pests if not properly attended too, contributes to factors causing low yield. This study, therefore, is intended to come up with the necessary information concerning the management of the said pests.

Botanical insecticides are naturally occurring chemicals extracted from plants. Natural pesticide products are available as an alternative to synthetic chemical formulations, but they are not necessarily less toxic to humans. Some of the most deadly, fast-acting toxins and potent carcinogens occur naturally. Botanical insecticides breakdown readily in soil and are not stored in plant or animal tissue. Often their effects are not as long lasting as those of synthetic pesticides and some of these products may be very difficult to find (Sharma et. al, 2012).

Sharma et al. (2012) estimated that over 2,000 plant species possess biological activity against insects, and the principal chemicals that impart such activity include alkaloids, terpenoids, acetogenins and flavonoids. Among the various plant products used as insecticides, nicotine from Nicotiana tabacum and pyrithrins from *Chrysanthemum cinerariaefolium* are the most prominent. Pesticide formulations developed from neem (*Azadirachta indica*), karanja (*Pongamia glabra*), and custard apple (*Annona squamosa*) have also shown promise for pest management. Despite voluminous information on the usefulness of these products as pest control chemicals, their exploitation in practical agriculture is limited due to low toxicity, latent period of action, short shelf-life, rapid degradation, and limited spectrum of activity. However, there is a general prevailing belief that natural plant products are easily biodegradable, and thus, are considered safer as compared to synthetic pesticides.

Antonious et al. (2007) reported that a research is needed to provide alternative pesticide with minimal impact on human health and the environment. Farmers around the world have long used plant extracts to protect food and fiber from insects and mites. In their study, they found that peppers have shown particular promise as a source of botanical pesticides: Powdered chilli pepper deters the onion fly, Delia antiqua, from laying eggs. A chemical from hot peppers reduces growth of the spiny ballworm, Earias insulana and may repel cotton pests.

One of the most widely used botanical pesticides is derived from the extract of tropical neem tree, Azadirachta indica. It comes in two forms, azadirachtin solution and neem oil. Unlike the other botanical insecticides, neem does not poison insects outright. Instead, when insects eat the active ingredient, it interrupts their ability to develop and grow to their next life stage or lay eggs. It also deters insects from feeding and is effective against aphids, thrips, ants, caterpillar, beetles, leafminers and others.

Neem as botanical pesticide supplies at least two compounds, azadirachtin and salannin that have insecticidal activity and other unknown compounds with fungicidal activity. Neem has been used for more than 4,000 years for medicinal

and pest control purposes in India and Africa. It is not highly toxic to mammals.

A neem-based pesticide, margosan-0, has shown to control gypsy moths, leaf miners, sweet potato white flies, western flower thrips, loopers, caterpillars and mealy bugs. This product is use on ornamentals, foliage plants, trees, shrubs and other non-food products.

Plants can absorb neem so that any insects that feed on them may be killed or deterred from feeding.

Extracts from the neem tree have been reported to control over 200 types of insects, mites and nematodes. The neem spray solution should not be exposed to sunlight and must be prepared with water having a temperature between 50 and $90^0$F. The solution is effective for only eight hours after mixing.

Hot-pepper wax is a botanical product used primarily as an insect repellent. The blend of capsaicin and food-grade paraffin wax is a metabolic stimulant for many soft-bodied insects. Hot-pepper wax acts to repel pests for up to three weeks (Collins, 2012).

Botanical pesticides were prepared in two ways: twenty (20) g of ground dried pepper were shaken with ten (10) drops of detergent in one hundred (100) ml of water, and fifty (50) g of fresh pepper was blended in 100 ml of alcohol for two (2) minutes.

Many of the hot peppers tested killed cabbage loopers. Only one of the peppers tested repelled spider mites.

## OBJECTIVES OF THE STUDY

The study aimed to assess the efficacy of botanical pesticides in controlling insect pests of three pigeon pea varieties. Specifically, it is aimed to determine which of the botanical pesticides can effectively control insect pests of pigeon pea, find out which among the pigeon pea varieties has the least damage by insect pests, and to identify and recommend the best botanical pesticides to control insect pests of pigeon peas

## MATERIALS AND METHODS

The materials used in the study were: Pigeon Pea Varieties ($V_1$ - 0042 Red, $V_2$ - ICPL 87119 and $V_3$ - ICPL 7035), Botanical Pesticides Extract (neem leaves, yellow ginger and hot pepper fruits), inorganic fertilizer, bamboo pegs, meter stick, plastic straw/string, field note book, weighing scale, knapsack sprayer, and graduated cylinder.

***Planting Area***

A total land area of 335.5 square meters of the Research Department of Abra State Institute of Sciences and Technology, Main Campus, Lagangilang, Abra was utilized for the study.

***Source of Planting Materials***

Seeds of pigeon pea varieties were secured through the initiative of Dr. Inez Gonzales at the College of Agriculture, BSU, La Trinidad, Benguet.

***Statistical Designs and Treatments***

The research study was laid out following a Factorial Randomized Complete Block Design (FRCBD) with three replications. The total land area was divided into three blocks representing the replication. Each block was further subdivided into four plots representing the different treatments.

Main plot was Factor A which consisted of the different varieties while the sub-plot or Factor B were the various botanical pesticides.

Main-plot: Varieties (V)
$V_1$ – 0042 Red
$V_2$ – ICPL 87119
$V_3$ – ICPL 7035

Sub-plot: Botanical Pesticides Extract (B)
$B_0$ – Control
$B_1$ – Neem Leaves
$B_2$ – Yellow Ginger Roots/Tubers
$B_3$ – Hot Pepper Fruits

The different treatments were tagged by the use of bamboo pegs. Each plot measures 3 meters long and 2 meters wide. There were 36 plots used in the study. Please see Figure 1 in Appendix A.

***Source of Botanical Pesticides***

Botanical pesticides were secured locally as these are grown in the locality.

***Preparation of Botanical Pesticides***

**Neem Leaves Extract**

Procedure: Neem tree extracts were prepared according to the volume of spray solution required per treatment. Neem tree leaves were gathered a day before the application from the source. Then the leaves were chopped into small pieces.

Rate of Application: After chopping, add 10 liters of water for every 5 kgs of chopped neem leaves then soaked overnight. The extract was filtered by the use of muslim cloth, put in a bottle ready for use.

**Yellow Ginger Extract**

Chop 1 kilo of yellow ginger tubers. Pound the materials to extract the juice. Filter the solution with muslim cloth. Mix 2 liters of water. Mix 1 liter of extract to 6.5 liters of water.

**Hot Pepper Fruit Extract**

Collect/Gather, wash and clean ripe hot pepper fruits. Chop/cut hot pepper fruits into pieces. Pound/grind hot pepper fruits to extract the juice or liquid. Filter the juice with muslim cloth. Mix 2 tbsp to 1 gallon of water.

***Cultural Management***

**Land Preparation**. One month before planting, the area was plowed by the use of a carabao-drawn plow to kill and incorporate all weeds in the area for proper decomposition. After plowing, harrowing was done several times to properly pulverize the soil for easier planting and facilitate fast emergence of seedlings.

**Planting.** After preparing the land thoroughly, the experimental plots were laid out following a Factorial Randomized Complete Block Design (FRCBD).

Pigeon Pea seeds of short duration lines $V_3$ (ICPL 7035), and the medium duration lines $V_1$ (0042 Red) and $V_2$ (ICPL 87119) were planted at a distance of 100 cm x 30 cm between furrows. Three seeds were planted per hill at a depth of 5 cm.

**Replanting**. The missing hills of pigeon pea plants were replanted at 15 days after planting.

**Fertilizer Application.** Basal application of complete fertilizer was done before planting. Basal application of complete fertilizer (14-14-14) was applied at the rate of 4 gm. /hill before planting.

**Irrigation.** Irrigation was employed just after planting and succeeding irrigations were done as often as necessary. The pigeon pea plant was irrigated through furrow irrigation by the use of water pump.

**Weed Management.** The whole experimental area was kept weed-free throughout the duration of the study. Spot weeding was done to remove weeds growing along the ridge and between plants.

**Insect Management.** Insect pests were monitored weekly starting from 21 days after planting. The recommended botanical pesticide was sprayed only at critical pest level.

**Application of Botanical Extract.** Application of hot pepper extract was done during vegetative and reproductive stage of pigeon pea. Other botanical extract tested followed with the required dosage of application.

***Data Collection and Analysis***

Two inner rows in the plot constituted the sampling area. For growth and yield parameters, 10 sample plants within the effective sample area were randomly selected and tagged for easy identification.

**Data gathered were the following:**

**Plant height** – the heights of ten sample plants from the inner rows were measured from the base up to the tip of the shoot at 80 days after planting.

**Number of days from planting to emergence** was counted. (50% emergence of plants)

**Number of days from emergence to flowering** was counted. (50% of plants)

**Degree of pest damage.** (per hill of sample plants). This was evaluated counting the number of leaves showing holes using the scale:

| Scale | - | Description |
|---|---|---|
| 1 | - | Sound |
| 2 | - | 1-10 holes (Light) |
| 3 | - | 11-20 holes (Medium) |
| 4 | - | 21-above holes (Severe) |

**Percentage of Infestation** (leaves, flowers, pods of sample plants). The leaves

were examined for damages at vegetative and reproductive stage. The percentage of leaves with damage was determined using the formula:

$$\textit{Damage leaves (\%)} = \frac{\textit{Number of damaged leaves}}{\textit{Total Number of leaves per plant}} \times 100$$

$$\textit{Pod damage (\%)} = \frac{\textit{Number of pods damaged}}{\textit{Total number of sample pods}} \times 100$$

*Pod damage per plot = Ave. no. of damage pods/hill x no. of hills*

**Identification of Insect Pests**

All the data were analyzed statistically using Factorial Randomized Complete Block Design.

## RESULTS AND DISCUSSION

***Identification of Insect Pests on Pigeon Pea***

**Pod Borer** – Adult moths have dull brown forewings. A single female can lay up to 2000 small eggs, usually single. Eggs are laid on flower buds and young pods. Full-grown larvae are 30-40 mm long and may have various color and banding patterns. Pupation occurs in the soil or plant debris. It destroys buds, flowers and pods. Larvae also feed on foliage of pigeon pea. The presence of pod borer in the study was evident prior to application of botanical pesticide.

**Fruit Worm –** feeding on the leaves and flowers of pigeon pea. It may have migrated from the neighboring tomato plantation.

The following insect pests were also noticed during the monitoring of the sample plants of the study: **Plume moths** – adults have brown plume-like wings; larvae are green or brown, spindle-shaped and covered with short spines. Larvae chew into the buds flowers and pods and small holes are seen in the buds and tender pods. **Pod Flies** – the adult is a small black fly. The larvae are white legless and 3 mm long. They feed inside the green seed. **Pod Wasp –** the adult is a small wasp of 2 mm long. The legless white larvae (3 mm long) feeds on the young green seed and inner pod wall. Attacked locules remain undeveloped resulting in abnormal appearance of the pods. **Other pests** noticed were aphids, leafhoppers, katydids, adult beetles, cowbugs, ants and some friendly insects like spiders.

**Growth Parameters**

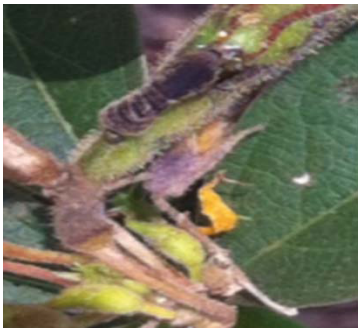

Figure 1. Pod Borer

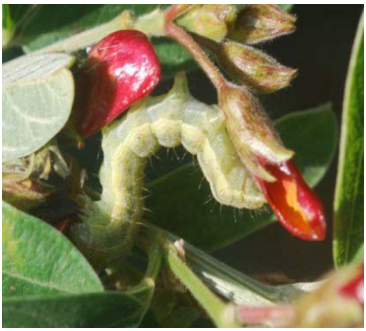

Figure 2. Fruit Worm

Figure 3. Pod Wasp

***Height of plants***

**Variety.** The height of plants at 85 days after planting as affected by variety is presented in Table 1a. $V_1$ (0042 Red) obtained the tallest height with a mean of 95.62 cm. $V_3$ (ICPL 7035) did not differ significantly with the height of $V_2$ (ICPL 87119) with a mean of 74.58 and 77.43 cm., respectively.

Analysis of variance showed a significant difference among the treatments which means the different pigeon pea varieties tested showed variation on their growth.

Table 1a. Height of plants at 85 days after planting as affected by variety

| Variety | Mean |
|---|---|
| $V_1$ – 0042 Red | 95.62[b] |
| $V_2$ – ICPL 87119 | 77.42[a] |
| $V_3$ – ICPL 7035 | 74.58[a] |

**Botanical Extracts Application.** The height of plants at 85 days after planting as affected by botanical extract application is presented in Table 1b. Pigeon pea varieties applied with yellow ginger extract had registered the tallest height with a mean of 83.6 cm. but did not differ significantly to the height of plants applied with neem leaf extract and hot pepper extract with a mean of 82.8 and 83.0 cm. respectively.

Table 1b. Height of plants at 85 days after planting as affected by botanical extract application

| Botanical Extract | Mean |
|---|---|
| $B_0$ – Control | 81.7 |
| $B_1$ – Neem Leaf Extract | 82.8 |
| $B_2$ – Yellow Ginger Extract | 83.6 |
| $B_3$ – Hot Pepper Fruits Extract | 82.0 |

**Interaction effect on the height of plants by variety x botanical extracts application.** No significant interaction effects were noted between varieties and botanical extract on the height of plants at 85 days after planting. These results signify the absence of influencing effects between the two factors studied.

**Effects on Germination**

**Variety**. The emergence of the pigeon pea plants from the date of planting is shown in Table 2. $V_1$ (0042 Red) emerged slightly ahead followed by $V_2$ (ICPL 87119) and $V_3$ (ICPL 7035) ranging from 8-12 and 10-15 days respectively. Some missing hills were replanted 16 days after planting.

**Botanical extracts application.** No botanical extract application was done yet from planting to emergence of pigeon pea plants.

**Interaction effect on the number of days from planting to emergence by variety x botanical extract application**. No interaction was observed between variety and botanical extract application since at this period botanical extract application was not yet done.

Table 2. Number of days from planting to emergence

| Variety | Range |
|---|---|
| $V_1$ – 0042 Red | 8 – 12 |
| $V_2$ – ICPL 87119 | 10 – 15 |
| $V_3$ – ICPL 7035 | 10 – 15 |

**Emergence to Flowering**

**Variety.** Table 3 showed the number of days from emergence of the pigeon pea varieties to flowering stage. The data was obtained when 50% of the plants exhibited fully matured flowers or early pod development. $V_3$ (ICPL 7035) showed to have the earliest flowering stage at 80-90 days, followed by $V_2$ (ICPL 87119) at 86-95 days while $V_1$ (0042 Red) bear its 50% flowers at 90-100 days.

**Botanical extracts application**. Data on the effect of the number of days from emergence to flowering as influenced by botanical extract application were not reflected since this growth variable is attributed to the variety of the pigeon pea and not botanical extract application and consequently no interaction effect between the two variables was noted.

Table 3. Number of days from emergence to flowering (50%)

| Variety | Range |
|---|---|
| $V_1$ – 0042 Red | 90-100 |
| $V_2$ – ICPL 87119 | 85-95 |
| $V_3$ – ICPL 7035 | 80-90 |

**Leaf Damage Assessment Before Botanical Extracts Application**

**Variety.** Table 4a presents the initial assessment of the degree of damaged leaves per plant as influenced by variety. As shown on the table prior to the application of the treatments, $V_1$ (0042 Red) and $V_3$ (ICPL 7035) had damaged leaves rating of 2.050, however it is comparable to the damaged leaves rating of $V_2$ (ICPL 87119) with 2.000.

The analysis of variance showed no significant differences among the treatment means. The result implies that prior to the application of botanical extracts; all the plants exhibited almost the same condition of insect damage on the pigeon pea leaves.

Table 4a. Initial assessment of degree of damaged leaves of pigeon pea plants as affected by variety

| Variety | Mean |
|---|---|
| $V_1$ – 0042 Red | 2.050[a] |
| $V_2$ – ICPL 87119 | 2.000[a] |
| $V_3$ – ICPL 7035 | 2.050[a] |

**Botanical extracts application.** Table 4b shows the initial assessment of damaged leaves on pigeon pea plants as influenced by botanical extracts. The plants treated with $B_1$ (neem leaf extract) had significantly higher damaged leaves rating compared to pigeon pea plants applied with hot pepper extract. However, it did not differ significantly on the damaged leaves assessment of plants. Plants applied with $B_2$ (yellow ginger extract) exhibited the least damaged leaves assessment.

Table 4b. Initial assessment of the degree of damaged leaves of pigeon pea plants before botanical extracts application

| Treatment | Mean |
|---|---|
| $B_0$ – Control | 2.022 |
| $B_1$ – Neem Leaf Extract | 2.089 |
| $B_2$ – Yellow Ginger Extract | 1.956 |
| $B_3$ – Hot Pepper Fruit Extract | 2.067 |

**Interaction on the initial assessment of the degree of damaged leaves by variety x botanical extracts application.** No significant interaction effects were observed between varieties and botanical extract application on the initial assessment on the degree of damage. These results meant the absence of synergistic effects of the two factors studied.

**Leaf Damage Assessment After Botanical Extracts Application**

**Variety.** Assessment of the degree of damaged leaves of pigeon pea plants after botanical extracts application as affected is shown in Table 5a. $V_2$ (ICPL 87119) showed a significant difference in having the least degree of damaged leaves at 1.888 compared to $V_1$ (0042 Red) and $V_3$ (ICPL 7035) with a rating of 2.377 and 2.154, respectively.

ANOVA showed highly significant differences among treatment means. The Duncan Multiple Range Test showed that $V_3$ (ICPL 7035), and $V_1$ (0042) Red were not significantly different from each other but were significantly different from $V_2$ (ICPL 87119).

Table 5a. Assessment of the degree of damaged leaves of pigeon pea plants after application of botanical pesticides

| Variety | Mean |
|---|---|
| $V_1$ – 0042 Red | $2.377^{b}$ |
| $V_2$ – ICPL 87119 | $1.888^{a}$ |
| $V_3$ – ICPL 7035 | $2.154^{ab}$ |

**Botanical extracts application.** Table 5b showed the effect of botanical extract on the degree of damaged leaves after application.

Evidently, results showed that spraying with the different botanical extracts had an effect in controlling the insect pests of pigeon pea as shown on the treatment means with $B_0$ (Control) having the highest degree of damaged leaves.

Table 5b. Assessment of the degree of damaged leaves of pigeon pea plants after application of botanical pesticides.

| Treatment | |
|---|---|
| $B_0$ – Control | 2.229 |
| $B_1$ – Neem Leaf Extract | 2.007 |
| $B_2$ – Yellow Ginger Extract | 2.162 |
| $B_3$ – Hot Pepper Fruit Extract | 2.162 |

**Interaction on the assessment of the degree of damaged leaves after application by variety x botanical extract application.** No significant interaction was observed on the degree of damage after application on the variety, and the botanical extracts applied reflecting that the action of the two factors were not related on these parameters.

**Initial Percentage of Leaf Damage**

**Variety.** Table 6a showed the initial percentage of leaf damage per pigeon pea plant prior to application of botanical pesticides, with $V_2$ (ICPL 87119) having the least percentage of damage leaves at 16.05% followed by $V_3$ (ICPL 7035) and $V_1$ (0042 Red) with 18.32% and 20.63% respectively.

ANOVA showed no significant difference among the treatments prior to the application of botanical extracts.

Table 6a. Initial percentage of leaf damage per pigeon pea plant

| Variety | Mean |
|---|---|
| $V_1$ – 0042 Red | $20.63^{b}$ |
| $V_2$ – ICPL 87119 | $16.05^{a}$ |
| $V_3$ – ICPL 7035 | $18.32^{ab}$ |

**Botanical extracts application.** Table 6b showed that $B_2$ (Yellow Ginger Extract) has the least % of infestation with 16.62%, followed by $B_0$ (Control), $B_1$ (Neem Leaf Extract), and $B_3$ (Hot Pepper Extract) with 18.23%, 19.16% and 19.33%, respectively.

Table 6b. Percentage of leaf damage per pigeon pea plant before application of botanical extracts

| Treatment | |
|---|---|
| $B_0$ – Control | 18.23 |
| $B_1$ – Neem Leaf Extract | 19.16 |
| $B_2$ – Yellow Ginger Extract | 16.62 |
| $B_3$ – Hot Pepper Fruit Extract | 19.33 |

**Interaction on the percentage of leaf damage by variety x botanical extracts application.** No significant interaction effects between variety and botanical extract application were observed on the % of infestation before application indicating that the two factors acted independently.

**Percentage of Leaf Damage after Application of Botanical Extracts**

**Variety.** The percentage of leaf damage per pigeon pea plant after spraying botanical extracts is shown in Table 7a. $V_2$ (ICPL 87119) showed the best

result in responding to botanical pesticide by having the least damage leaves at 13.80%, followed by $V_1$ (0042 Red) and $V_3$ (ICPL 7035) with 20.58 and 21.08 respectively.

Analysis of variance showed highly significant differences among the treatment means. The result implied that $V_2$ (ICPL 87119) might have a greater degree of resistance to the attack of pests compared to the two treatments, thus resulted to least percentage of damaged leaves.

Table 7a. Percentage of leaf damage per pigeon pea plant after botanical extracts application

| Variety | Mean |
|---|---|
| $V_1$ – 0042 Red | $20.58^b$ |
| $V_2$ – ICPL 87119 | $13.80^a$ |
| $V_3$ – ICPL 7035 | $21.08^b$ |

**Botanical extracts application.** Table 7b shows that $B_3$ (Hot Pepper Fruit Extract) had the least percentage of leaf damage with 15.8%, followed by $B_1$ (Neem Leaf Extract), $B_0$ (Control), and $B_2$ (Yellow Ginger Extract) with 17.7%, 19.9% and 20.5%, respectively.

ANOVA showed insignificant differences among the treatments.

Table 7b. Percentage of leaf damage per pigeon pea plant after botanical extracts application

| Treatment | Mean |
|---|---|
| $B_0$ – Control | 19.9 |
| $B_1$ – Neem Leaf Extract | 17.7 |
| $B_2$ – Yellow Ginger Extract | 20.5 |
| $B_3$ – Hot Pepper Fruit Extract | 15.8 |

**Correlation Analysis**

Table 8 showed the correlation analysis among the varied factors. Comparing the degree of damage before and after application results showed a non-significant result. The insignificant result might be attributed to the fact that the degree of damage observed before and after application are almost similar.

Table 8. Correlation analysis

| Paired Samples | | N | Correlation | Sig. |
|---|---|---|---|---|
| Pair 1 | Degree of Leaf Damage Before and After Application | 12 | -.176 | .584$^{ns}$ |
| Pair 2 | Degree of % Infestation Before and After Application | 12 | .280 | .379$^{ns}$ |
| Pair 3 | Insect Counts Before and After Application | 60 | .645 | .000** |
| Pair 4 | Degree of Leaf Damage & % Infestation Before Application | 12 | .671 | .017* |
| Pair 5 | Degree of Leaf Damage & % Infestation After Application | 12 | .679 | .015* |

ns not significant
** highly significant
* significant

Likewise, the correlation analysis between percentage infestation before and after application showed insignificant result. This is because botanical extract applied to the pigeon pea plants did not show immediate reduction on pest damage on the sample plants.

In terms of monitoring the insect count before and after application, the correlation analysis showed a significant result. The result implied that the botanical extract applied to the pigeon pea plants exhibited a significant effect in terms of controlling the pests. The correlation analysis between the degree of damage and the percentage infestation before application showed a significant result. The data implied that the pigeon pea plants applied with botanical extract showed variation on degree of damage and the percentage infestation. This could be attributed to the efficacy of the botanical pesticides.

Similarly, a significant result was noted on the degree of damage and percentage infestation after application of botanical pesticides. The result implied that after application of botanical extracts, the degree of infestation that resulted to a least degree of damage to the pigeon pea plants had been reduced.

**Pod Damage**

**Variety.** Samples were taken in V3 (ICPL 7035). The percentage of pod damage per pigeon pea plant after spraying botanical extracts is shown in Table 9.

**Botanical extracts application.** The efficacy of the extracts is reflected in Table 9. The plants treated with $B_2$ (Yellow Ginger Extract) exhibited the least percentage of damaged pods with 4.14% followed by plants treated with $B_3$ (Hot Pepper Fruit Extract) and $B_1$ (Neem Leaf Extract) with a mean of 8.57% and 8.9%, respectively. The $B_0$ (Control) recorded the greatest percentage of damaged pods with 10.47%.

The ANOVA showed insignificant result.

Table 9. Percentage of pod damage per pigeon pea plant after application of botanical extracts

| Treatment (V3 – ICPL 7035) | Mean |
|---|---|
| $B_0$ – Control | 10.47 |
| $B_1$ – Neem Leaf Extract | 8.90 |
| $B_2$ – Yellow Ginger Extract | 4.14 |
| $B_3$ – Hot Pepper Fruit Extract | 8.57 |

**Interaction effect on pod damage by variety x botanical extracts application**

No significant interaction effect comparison between varieties and botanical extracts application because only ICPL 7035 variety has pods during the assessment of damaged pods.

This wide range in terms of percentage of pod damage was due to the unpredictable behavior and mobility of the larvae during the larval stage, which is considered the most active period in the life cycle of the insect pests. The larvae of these identified pests can create devastating pest outbreaks anytime depending on the existing conditions during this life cycle stage (Global Food Security, 2009).

However, assessment of the total damages done by the different pests during the observation period using the revised pigeon pea leaf damage assessment chart was low to moderate. According to Hutchison, Bolin, and Hines (2003), larvae of DBM cease to feed when the temperature drops below 50 $^0$F. Like other insects, their development through all life stages is delayed during cool temperatures. In contrast, populations can increase dramatically when temperatures rise above 80 $^0$F. Life cycles of the insects may take as long as 50 days to complete their life cycle at low temperatures and as short as 15 days at high temperatures.

## CONCLUSIONS

Based on the results of the study, conclusions were drawn. Firstly, distinct pigeon pea pests were identified to pose alarming damages to pigeon pea production in Lagangilang, Abra when not properly controlled and managed. The application of $B_2$ (Yellow Ginger Extract), $B_3$ (Hot Pepper Fruits Extract) and $B_1$ (Neem Leaf Extract) can effectively control pests of pigeon pea. Secondly, $V_2$ (ICPL 87119) pigeon pea variety had the least damage by insect pests during the duration of the study. Thirdly, $B_3$ (Hot Pepper Extract) showed the best figure but $B_1$ (Neem Leaf Extract) and $B_2$ (Yellow Ginger Extract) are comparably effective in controlling pests of pigeon pea during the conduct of the study.

## RECOMMENDATIONS

Based on the above conclusions, the following are recommended: $B_1$ (Neem Leaf Extract), $B_2$ (Yellow Ginger Extract) and $B_3$ (Hot Pepper Extract) can be used to control insect pests of pigeon peas; $V_2$ (ICPL 87119) is recommended for production in Abra due to its resistance to pests; and the conduct of a similar study to determine the efficacy of botanical pesticides using different combinations of the same botanical extracts in controlling pigeon pea pests.

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