## BIBLIOGRAPHY

BANGSOYAO, EUNICE K. APRIL 2009. Effect of Inoculation on the Seed Yield of Garden Pea Accessions under Bangao, Buguias, Benguet condition. Benguet State University, La Trinidad Benguet.

Adviser: Danilo P. Padua, Ph.D.

## ABSTRACT

These study was conducted to determine the effect of inoculation on the nodulation, growth and seed yield of garden pea; to determine the garden pea accessions that best responds to inoculation; to determine the interaction of inoculation and garden pea accessions; and to determine the profitability of using inoculant on the garden pea accessions under Bangao, Buguias, Benguet condition.

Rhizobium inoculation significantly affected nodule count and seed yield of the garden pea accessions. Among the six garden pea accessions inoculated, CGP 34 significantly outperformed the other accessions in terms of nodule count and CLG, CGP 34 and CGP 13 also produced the highest seed yield per plot. In all the parameters measured no significant interaction effects were observed between inoculation and the garden pea accessions except for the nodule count and total seed yield per plot. In terms of the return on cash expense, inoculation gave the highest return of 11.53%.

# INTRODUCTION

There is money in garden pea (*Pisum sativum*). It is not only a popular vegetable but also commands a high market price which at times exceeds PhP 100 per kilo.

Garden pea, locally known “sweet pea” or “citzaro” is an annual legume grown for its edible pods and matured seeds. In Benguet where the weather is generally cool throughout the year, garden pea is not difficult to grow as this crop generally favor a relatively cool climate and, it yield in about three months (HARRDEC, 1996).

Garden pea is rich in nutritional value and good source of proteins and vitamins. The fresh green pods contain about 0.3g fat, 57 calorie, 3.3g proteins, 13.0g carbohydrates and 35.0g minerals per 100g edible portion (Purseglove, 1972). The seeds are also processed into canned products while the by products and vines are used as animal feeds (Purseglove, 1972).

Legumes crops can symbiotically fix nitrogen in association with rhizobium. If the legume crop is used as green manure, considerable amounts of N can be supplied to the succeeding crop as the residues decompose (Badaruddin and Meyer, 1990: Welty et al.,1998).

Inoculation is known to have important role in legume production. Inoculation or introducing proper strain of bacteria to legume seeds intended for planting by adding rhizobium will allow the legume to secure nitrogen from the air (Pog-ok, 2001).

Pascua (1996) stated that inoculation increase the nitrogen content and there are benefits derived such as prevention of early starvation, the reduction of demand for soil nitrogen and the improvement of grain and protein yield.

Excessive or improper use of chemical fertilizers may lead to serious environmental problems. Most farmers apply high inputs of synthetic fertilizer to supply nitrogen which has a short term effect. Furthermore, synthetic fertilizers are causing problems to soil and water. Biofertilizers and microbial inoculants are viewed as a plausible alternative to chemical fertilizers as far as sustainable agriculture is concerned (Puyongan 1997). This study will provide information on minimizing inputs and reducing cost.

Inoculation or fertilization plus inoculation may increase N-content , N-accumulation of the leaves and stems, nodule count and vine length, plant height, nitrogen balance in the soil after harvest, dry matter production and pod setting percentage , marketable and non-marketable pods, pod yield and weight of seed of garden pea.

The study was conducted to:

1. determine the effect of rhizobium inoculation on the nodulation, growth and seed yield of garden pea accessions under Bangao, Buguias, Benguet condition;

2. determine the garden pea accessions that best responds to inoculation under Bangao, Buguias, Benguet condition;

3. determine the interaction effect of inoculation and garden pea accessions; and

4. determine the profitability of using inoculatns on the garden pea accessions under Bangao, Buguias, Benguet condition.

This study was conducted at Bangao, Buguias, Benguet Condition from November 2008 to March 2009.

**REVIEW OR LITERATURE**

Legumes and Rhizobia

Mckey (1994) stated that the ability to fix $N_2$ in association with bacteria actually evolved in legumes in response to the demands of maintaining high leaf N concentration. Legumes developed N-rich leaves to begin with because the efficiency of photosynthesis increases the tissue N concentration. Beijerinck (1988) stated that pure culture of the bacteria was shown to induce nodule when reinoculated on the same pea plant.

Manguiat *et. al* (1980) further noted that rhizobial inoculation significantly increased the nodule weight and number during the first cropping but the effect of rhizobial inoculation on nodulation was no longer detected during the succeeding legume crop.

Bishop *et.al* (1983) explained that the relationship between bacteria and the legume plants is considered a symbiotic one, two organisms living together for their mutual benefit. Legumes provide carbohydrates (food) and water to the bacteria in turn bacteria fixes nitrogen. FAO (1989) reported that inoculation of legumes with rhizobium increase nodulation, nitrogen fixation and yield of the crop. The same report shows that a combination of rhizobium and phosphate-solubilizing bacteria (PSB) substantially increased the yield nitrogen uptake, nodulation and nitrogenous activity in chickpea.

Assimilation of Biologically Fixed Nitrogen

Ludwig (1984) stated that nitrogen derived from $N_2$ fixation in obtained first in the form of ammonia. Generally, this will be protonated to form ammonium ($NH_4^+$) ions, which must be assimilated. This assimilation may be by the $N_2$ fixing organism itself, in which case the organism can feed directly on $N_2$ and can correctly be termed a diazotroph. In legume symbiotic associations however, the fixed nitrogen is assimilated not by the prokaryotic symbiont but by the host plant. There is considerable evidence indicating that neither rhizobium nor rhizobium species can grow on the products of the $N_2$ fixation, and this strictly they not diazotroph.

The ability of the legume crops to fix atmospheric nitrogen often result in a lower utilization of in organic nitrogen sources in the soil profile as compared to non fixing crops (Jensen, 1989). In this way in organic nitrogen in conserved for the following crop unless it is lost by volatilization, leaching or denitrification.

Nodulation and $N_2$ - Fixation Activity

Nodulation comes about due to the symbiotic association between rhizobium bacteria and the legumes, the atmospheric nitrogen available for rhizobium species to its legumes host which, in turn, provide shelter and food to the bacteria. Nitrogen fixation occurs in root nodules and is mediated by resting cells of rhizobium utilizing a source energy supplied internally through the host (Pearson and Adams, 1976).Nitrogen fixation have high potential benefits to soil and high legume production (Peoples et.at 1989) .

Devlin and Witham (1983) stated that generally the fixation of nitrogen is inhibited by ammonia or nitrate. These compounds do not interfere with the mechanisms of nitrogen fixation, but merely are preferred to molecule as nitrogen source.

Alexander (1977) stated that because fixation serves as a means of obtaining nitrogen required for growth it is surprising that simple inorganic compounds inhibit nitrogen fixation. However, nitrogen depresses the internal carbohydrates supply and has retarding influence on nodulation.

Usually when mature nodules begin to lose their bacteriology active period and become old, new ones are formed in new root growth in most of the legumes, particularly in biennial and perennial and even in common bean. However, the ability to form new nodules to replace the old ones highly depends upon the rhizobial genotype and its interaction with the host genotype (Padua,1997).

Rhizobium, upon infection of the appropriate legume can cause the formation of nodules and participate in the symbiotic acquisition of nitrogen. The root nodules are important in nitrogen fixation, their development on the roots determine the survival of the plant particularly at a low level of nitrogen (Alexander, 1997). Moreover, if the proper strain is present and the nodules formed, the legume plants use little soil nitrogen (Chapman and Carter, 1976).

Black (1976) as cited by Ramos (1991) mentioned that root nodules of legumes are of various sizes and shapes, and they differ in effectiveness in fixing nitrogen. The best visual criterion of effectiveness is probably the color. Effective nodules have pink or reddish centers and ineffective nodules have a greenish white center. In addition, there is a tendency for effective nodules to be relatively larger in size, fewer in number in the main roots and ineffective nodules to be relatively small in size, larger in number and scattered on the lateral or secondary roots. Both the effective and ineffective nodules may occur on a single plant. The number per plant may range from none to hundreds.

## Effect of Inoculation

Legumes have a good relationship with bacteria fixing atmospheric nitrogen for plant use. The amount of nitrogen fixed by the legumes depends on many factors: condition of the soil like aeration, drainage, moisture content and amount of chemical applied to the plants and the soil (Brady, 1985). Talusig (1996) stated that the growth of inoculated snap bean was significantly greater than those of uninoculated plants in terms of nodule count, nodule weight and final pH of the soil. There were significant interaction effect of snap bean and rhizobial strain on the weight of fresh leaves, stems, and roots and on the final pH of the soil. He also stated that the significantly greater nodulation of pole snap bean attribute to fibrous roots that bore more nodules. It is widely claimed that the N content of the plants tissue is significantly increased by inoculation this may also true to garden pea.

Hill (1994) also noted that legumes do not always nodulate when introduced in the soil. Even in soil which rhizobia are present, they may not be effective such as they may not produce much nitrogen. If fully effective, they may not be present in sufficient numbers to promote prompt and adequate nodulation. For these reasons, it had been found necessary for the farmers to introduce the rhizobia to the soil. This is done by seed inoculation when the pasture or crops is grown. Inoculation is desirable when there is doubt about the soil containing the bacteria in abundance. In contrast, the author also mentioned that most growers do not inoculate their seeds. They feel it is simpler to provide the nitrogen for legumes in fertilizer form rather than by inoculation.

Evaluated legumes that was inoculated produced the long vine, also had significantly heavier fresh and dry weight of pods which was not constructed as due to its greater yield potential but merely as a result of its earlier maturity, also has high number of root nodule that attribute to the greater fibrous roots that bore more nodules resulting to positive response to inoculation. It also increase soil pH, soil nitrogen and, plant nitrogen Puyongan (1997). High vigor, ability to withstand stress, diseases and pest, and good marketable yield and desirable qualities in a variety, and that nutrition in health value maybe used to distinguish varieties in the future.

## MATERIALS AND METHODS

Land Preparation and Planting

A total land area of 180 $m^2$ was prepared two to three weeks before sowing. The area was divided into three blocks. Each block was divided into 12 plots measuring 1m x 5 m. Two to three seeds were sown per hill at a distance of 20 cm between rows and hills. The treatments were laid-out following the split-plot design with three replications.

The treatments are as follows:

Main plot (Inoculation)

| Code | Treatment |
|---|---|
| $I_1$ | Uninoculated |
| $I_2$ | Inoculated |

Subplot (Garden Pea Accessions)

| Code | Accessions | Source |
|---|---|---|
| $V_1$ | CGP 13 | BSU |
| $V_2$ | CGP 59 | BSU |
| $V_3$ | CGP 110 | BSU |
| $V_4$ | CGP 18A | BSU |
| $V_5$ | CGP 34 | BSU |
| $V_6$ | CLG (check) | BSU |

Seed Sterilization

Uniform and undamaged seeds were surface sterilized by immersing in (70%) alcohol for 2-3 minutes, then washed 5 times in sterile distilled water, surface sterilized by immersing them in Sodium hypochlorite (25%) for 5 minutes and then washed in sterile distilled water for at least six times (Somasegaran and Hoben, 1994).

Seed Inoculation

Sterilized seeds were mixed thoroughly with the inoculants using direct coating method of inoculation. Seeds were placed in a paper box then sufficient amount of inoculants was added to completely and uniformly coat the seeds. Seeds were spread on clean blotting paper and air dried.

Data Gathered:

1. Plant maturity

a. Number of days from sowing to emergence. This was recorded by counting the number of days from sowing to emergence.

b. Number of days from emergence to first flowering. This was recorded by counting the number of days from emergence to the time when at least 50% of the plants in the plot have fully opened flowers.

c. Number of days to pod setting. This was done by counting the number of days from flowering until the pods were fully developed.

d. Number of days from pod setting to first harvest. This was obtained by counting the number of days from pod setting to first harvest.

2. Nodules

a. Nodule count. This was gathered by counting the numbers of root nodule at 40 DAP.

b. Nodule weight. Plant samples were up rooted and washed carefully to facilitate the removal of the nodules.

1. Nodule fresh weight (g) – the nodule was gathered and weighed

2. Nodule dry weight (g) – nodules was air dried and oven dried at 40 $^{0}$C before weighing.

3. Nitrogen content of the soil (%). Soils were gathered and brought to the Bureau of soils and water management San Fernando, La Union for the initial and final nitrogen content analysis.

4. Initial and Final pH of the soil. Soils were gathered and soil to the Bureau of soils and water management San Fernando, La Union for soil pH analysis.

5. Reaction to leaf miner and powdery mildew

a. Reaction to leaf miner. The resistance of different varieties of garden pea to leaf miner was rated at the peak of harvesting fresh pods following this rating (Buena, 2004).

| Scale | Percent infestation | Description |
|---|---|---|
| 1 | No damage | Highly resistant |
| 2 | 1-25% of total leaves per plant and per plot infested | Mildly resistant |
| 3 | 25-50% of total leaves per plant and per plot infested | Moderately resistant |
| 4 | 51-75% of total leaves per plant and per plot infested | Moderately susceptible |

| | | |
|---|---|---|
| 5 | 76-100% of total leaves per plant and per plot infested | Very susceptible |

b. Reaction to powdery mildew. This was determined using the following

| Scale | Percent infestation | Description |
|---|---|---|
| 1 | No damage | Highly resistant |
| 2 | 1-25% of total leaves per plant and per plot infested | mildly resistant |
| 3 | 25-50% of total leaves per plant and per plot infested | Moderately resistant |
| 4 | 51-75% of total leaves per plant and per plot infested | Moderately susceptible |
| 5 | 76-100% of total leaves per plant and per plot infested | Very susceptible |

6. Seed yield

a. Total seed yield per plot (g). This was gathered by getting the total weight of the seeds per plot.

b. Weight of 200 seeds (g). The weight of 200 seeds per treatment was recorded after five days of continuous sun drying.

7. Return On Cash Expense (ROCE). This was computed using the following formula:

$$ROCE = \frac{\text{Gross sales} - \text{Total expenses}}{\text{Total cost of production}} \times 100$$

Data Analysis

All the quantitative data gathered were subjected to analysis of variance (ANOVA). The significance of difference among means was tested using the Duncan's Multiple Range Test (DMRT) at 5% level of significance.

## RESULTS AND DISCUSSSION

Days from Sowing to Emergence of Garden Pea as affected by Inoculation and Different Accessions

Inoculation. Table 1 shows no significant differences on the number of days from sowing to emergence of garden pea as affected by inoculation. This finding signifies that rhizobium inoculation neither enhances nor delay seed germination or emergence.

Accessions. Analysis revealed that there were highly significant differences on the days from sowing to emergence as affected by the different accessions. Majority of the accessions emerged at 7 days. Only CGP 59 and CGP 34 emerged after one day later. Results show that the accessions have different response in the days from sowing to emergence.

Interaction Effect. No significant interaction existed between the inoculation and accessions of garden pea on the number of days from sowing to its emergence. This may be due to the same response of the different accessions to inoculation.

Number of Days from Emergence to Flowering

Inoculation. The number of days from emergence to flowering of garden pea as affected by inoculation is shown in Table 1. Analysis revealed that the number of days from emergence to flowering is not affected by inoculation.

Accessions. Analysis revealed marked differences on the days from emergence to first flowering as affected by the different accessions. It was noted that CGP 18A and CGP 13 were the first accessions to produce flowers in 37 days; followed about one week later by Chinese Light Green, CGP 59 and CGP 110, CGP 34 produced flower about two weeks later. This signifies that different accessions have different characteristics in response of emergence to flowering.

Interaction effect. There were no significant differences on the interaction between the inoculation and accessions of garden pea on the number of days from emergence to first flowering.

Table 1. Days from sowing to emergence, from emergence to first flowering, from flowering to pod setting, from pod setting to harvesting as affected by inoculation and garden pea accessions

| TREATMENT | NUMBER OF DAYS | | | |
|---|---|---|---|---|
| | TO EMERGENCE | FROM EMERGENCE TO FLOWERING | FROM FLOWERING TO POD SETTING | FROMPOD SETTING TO FIRST HARVEST |
| Inoculation (I) | | | | |
| Uninoculated | 7 | 42 | 12 | 37 |
| Inoculated | 7 | 42 | 12 | 37 |
| Accessions (A) | | | | |
| CGP 13 | $7^{a}$ | $37^{a}$ | $14^{c}$ | $37^{c}$ |
| CGP 59 | $8^{b}$ | $44^{b}$ | $10^{b}$ | $35^{a}$ |
| CGP 110 | $7^{a}$ | $45^{b}$ | $9^{a}$ | $35^{a}$ |
| CGP 18A | $7^{a}$ | $37^{a}$ | $12^{b}$ | $37^{c}$ |
| CGP 34 | $8^{b}$ | $48^{c}$ | $17^{c}$ | $41^{d}$ |
| CLG | $7^{a}$ | $43^{b}$ | $9^{a}$ | $36^{b}$ |
| I x A | $0.531^{ns}$ | $0.914^{ns}$ | $0.636^{ns}$ | $0.50^{ns}$ |
| CV (a) | 12.03 | 2.78 | 2.40 | 0.00 |
| CV (b) | 6.03 | 1.05 | 3.56 | 0.00 |

Number of Days from Flowering to Pod Setting

Inoculation. Table 1 also shows the number of days from flowering to pod setting of garden pea as affected by inoculation. No appreciable difference between the inoculated and uninoculated garden pea was observed.

Accessions. Differences were noted on the number of days from flowering to pod setting among the different accessions used (Table1 and Fig. 1). Chinese Light Green and CGP 110 produced pods the earliest at 9 days followed by CGP 59 and CGP 18A in 10 days and 12 days, respectively; lastly, CGP 13 and CGP 34 produced pods in 14 days and 17 days, respectively. The significant difference could be the effect of climate adaptation of the different accessions and their genetic characteristics.

Interaction Effect. No significant interaction was noted between inoculation and accessions on the number of days from flowering to emergence of garden pea.

Number of Days from Pod Setting to First Harvest

Inoculation. Table 1 shows no significant difference between inoculated and uninoculated garden peas in terms of the number of days from pod setting to first harvest. It was noted that both inoculated and uninoculated garden peas were harvested 37 days after pod setting.

Accessions. The same table shows significant differences on the days from pod setting to first harvesting of the garden peas as affected by the different accessions. CGP 59 and CGP 110 were harvested 35 days after pod setting while the other strains were harvested from 37 days to 41 days after pod setting. This result suggests that CGP 59 and CGP 110 were better accessions in terms of pod setting to first harvest.

(a) Vegetative stage

(b) Flowering stage

(c) Pod development

Figure 1. Plant stand at the different stages growth

Interaction effect. No significant interaction effect was noted between inoculant and accessions of garden peas on the number of days from pod setting to first harvest.

Nodule Count

Inoculation. Results revealed that inoculated garden peas significantly produced greater nodule count as compared to uninoculated garden peas (Table 2). This finding signifies that there is a significant effect of inoculation on the nodule count of garden pea. It was noted that inoculated garden pea produced an average of 165 nodules no. per 5 plant at 40 DAP which is relatively higher than the uninoculated garden pea with a mean of 135 nodules only. Table 2 shows that CGP 34 was the better accession since it had the highest number of nodule which is 168 as compared with the other accessions that had the nodule number of 154 to 137 only.

The result shows that inoculation of garden pea before planting promotes nodulation. This is similar to the findings of Manguiat *et al.* (1980) and FAO (1989) that rhizobial inoculation significantly increased the nodule count of the legume plant. It also coincides with the statement of Sanchez (1976) that the practice of inoculating seeds with the appropriate rhizobial strain promotes nodulation. It is therefore beneficial to inoculate garden pea seed to ensure production of nodules.

Accessions. Analysis also revealed significant differences on the nodule count of garden pea as affected by the different accessions (Table 2). It was observed that CGP 34 produced the highest number of nodules at 40 DAP with a mean of 168 nodules as compared to the other accessions which produced nodules of only 137 to 144 nodules only.

The result may be attributed to the formation of more fibrous roots of CGP 34 with greater potential of producing more nodules. This confirms with the statement of Alexander (1977) as cited by Ramos (1991) that legumes with fibrous root character frequently have greater nodule count.

Interaction effect. No significant interaction effect between the inoculation and accessions of garden pea on the number of nodule count was observed.

Table 2. Nodule count, nodule fresh weight and nodule dry weight at as affected by inoculation and garden pea accessions.

| TREATMENT | NODULE COUNT (No./5 PLANTS) | NODULE FRESH WEIGHT (g) | DRY WEIGHT (g) |
|---|---|---|---|
| Inoculation (I) | | | |
| Uninoculated | 135[b] | 0.51 | 0.26 |
| Inoculated | 165[a] | 0.70 | 0.30 |
| Accessions (A) | | | |
| CGP 13 | 144[c] | 0.52 | 0.26 |
| CGP 59 | 149[c] | 0.47 | 0.29 |
| CGP 110 | 147[c] | 0.52 | 0.24 |
| CGP 18A | 137[d] | 0.70 | 0.33 |
| CGP 34 | 168[a] | 0.84 | 0.34 |
| CLG | 154[b] | 0.59 | 0.23 |
| I x A | 0.721[ns] | 1.210[ns] | 2.068[ns] |
| CV (a) % | 6.58 | 24.32 | 37.46 |
| CV (b) % | 8.47 | 36.29 | 35.71 |

Nodule fresh weight

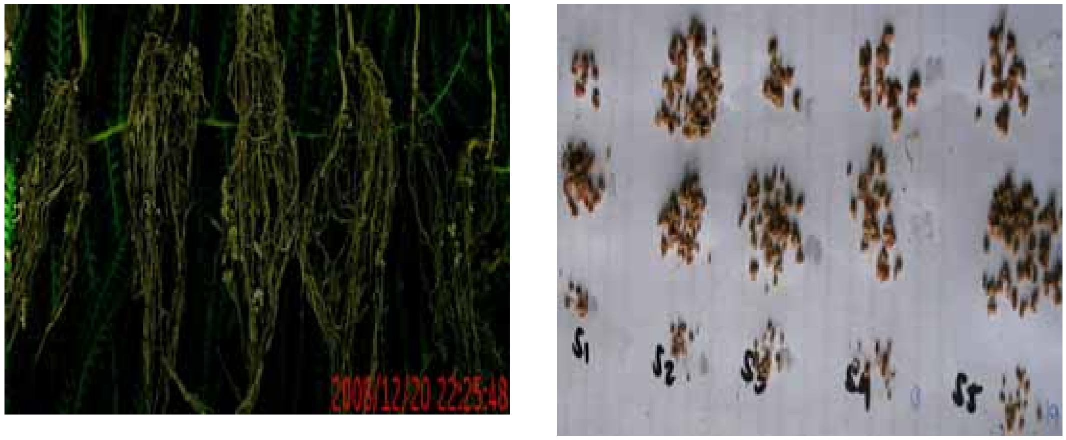
Inoculation. Table 2 shows the number of nodule weight of garden pea as affected by inoculation. Analysis revealed that there were no significant differences on the nodule weight for both inoculated and uninoculated garden pea. However, it was noted that inoculated garden pea produced a greater weight of 0.70 g as compared to uninoculated garden pea which produced a nodule weight of 0.51 g only. The difference on the nodule weight maybe attributed to the higher number and bigger size of nodules produced by inoculated garden pea as compared to uninoculated garden pea.

Accessions. The same table shows no significant differences on the nodule weight of garden pea as affected by the different accessions. It was noted that CGP 34 produced the heaviest nodule fresh weight of 0.84 g. followed by CGP 18A with 0.70 g and Chinese light green with 0.59 g, CGP 59 produced the lightest nodule fresh of 0.47 g only. This may be attributed to the differences on the genetic characteristics of the different accession in terms of nodulation as well as the number of nodules produced by the different varieties (Fig. 3).

Interaction effect. No significant differences were noted on the nodule weight of garden pea as affected by the interaction of inoculation and the different accessions.

Nodule Dry Weight

Inoculation. As shown in Table 2, no significant difference on the dry weight of nodules between the inoculated and uninoculated garden pea. Although inoculated garden pea appear to have produced a higher nodule dry weight of 0.30 g as compared to uninoculated garden pea with 0.26 g only.




(a) CGP 34  Inoculated

(b) CGP 34 Uninoculated

Figure 2.  Root nodule at 40 DAP

Accessions. The different accessions of garden pea have no significant differences on the nodule dry weight as shown on Table 2. However, numerical data shows that CGP 34 produced the highest nodule dry weight of 0.34 g as compared to the other accessions whose nodule dry weight ranges from 0.23 g to 0.33 g only.

Interaction effect. Analysis revealed no significant differences on the nodule dry weight of garden pea at as affected by the interaction of inoculation and the different accessions. Numerical data indicates that the total weighted mean of the nodule dry weight of the garden pea as affected by inoculation and accessions is 0.28 grams.

Final soil pH

Inoculation. Table 3 shows the final pH of the soil after harvest. It was noted that both uninoculated and inoculated garden pea have a final pH of 5.30 from the initial pH of 5.0. This indicates that inoculation was not significantly influenced the final pH of the and that any increase in soil pH maybe attributed to other factors.

Accessions. The final pH of the different accessions is shown in Table 3. CGP 13 had the highest final pH (6.10) while the other accessions has pH ranging from 5.00 to 5.45 only. This result shows that CGP 13 is the accession that has the potential to increase soil pH.

Final N Content

Inoculation. The final N-content of uninoculated and inoculated treatment is shown in Table 3. It was observe that inoculated treatment did not have any marked difference with the uninoculated treatment. It was noted through that there was an increase on the soil nitrogen content after harvest. The inoculant used was able to nodulate the plants but it was not effective in producing much nitrogen.

Accessions. Among the different accessions, it was observed that CGP 34 and CGP 18A had the highest N-content of 0.18 while the least N content of 0.14 was exhibited by CGP 59. It was noted that CGP 34 had the highest number and weight of nodules indicating its greater potential to fix nitrogen. This explains partly why CGP 34 and CGP 18A exhibited relatively higher nitrogen content.

Table 3. Soil pH and soil nitrogen as affected by inoculation and garden pea accessions

| | pH | N CONTENT |
|---|---|---|
| Inoculation (I) | | |
| Uninoculated | 5.31 | 0.158 |
| Inoculated | 5.25 | 0.166 |
| Accessions (A) | | |
| CGP 13 | 6.1 | 0.162 |
| CGP 59 | 5.45 | 0.137 |
| CGP 110 | 5.0 | 0.162 |
| CGP 18A | 5.0 | 0.175 |
| CGP 34 | 5.0 | 0.175 |
| CLG | 5.15 | 0.162 |
| Initial Analysis | 5.0 | 0.125 |

<u>Reaction to Leaf Miner</u>

<u>Inoculation</u>. Table 4 shows the reaction of garden pea to leaf miner as affected by inoculation. Data shows that uninoculated garden pea were mildly resistant to leaf miner while inoculated garden pea was moderately resistant to leaf miner. This implies that inoculation increase the resistance of garden pea to leaf miner.

Table 4. Resistance to leaf miner and powdery mildew as affected by inoculation and garden pea accessions.

| TREATMENT | REACTION TO: | |
|---|---|---|
| | LEAF MINER | POWDERY MILDEW |
| Inoculation (I) | | |
| Uninoculated | 2 | 3 |
| Inoculated | 3 | 3 |
| Accessions (A) | | |
| CGP 13 | 3 | 3 |
| CGP 59 | 2 | 3 |
| CGP 110 | 2 | 2 |
| CGP 18A | 3 | 2 |
| CGP 34 | 3 | 3 |
| CLG | 2 | 2 |
| I x A | $1.000^{ns}$ | $0.357^{ns}$ |
| CV (a) % | 14.40 | 5.58 |
| CV (b) % | 21.39 | 9.31 |

Rating scale: 1- highly resistant, 2 mildly resistant, 3- moderately resistant, 4 moderately susceptible, 5- very susceptible

Accessions. Table 4 shows the reaction of the different garden pea accessions against leaf miner. CGP 13, CGP 18A and CGP 34 were moderately resistant while CGP 59, CGP 110 and CLG were noted to be mildly resistant to leaf miner.

Interaction effect. Did not have significant interaction effects on resistance to leaf miner.

Resistance to Powdery Mildew

Inoculation. Table 4 shows the reaction of garden pea to powdery mildew as affected by inoculation. It was noted that both inoculated and uninoculated garden peas were rated (3) moderately resistant to powdery mildew

Accessions. CGP 13, CGP 59 and CGP 34 were rated moderately resistant to powdery mildew (Table 4). Both CGP 110and CLG were rated mildly resistant together with CGP 18A.

Interaction effect. There were no significant effects of the interaction of inoculation and accessions on the resistance of garden pea to powdery mildew.

Total Seed Yield per Plot (g)

Inoculation. Table 5 shows that inoculated garden pea produced greater total seed yield per plot with a mean of 251.29 g as compared to uninoculated garden pea with a mean of 235.380 g only.  This indicates the benefit that could be derived from inoculation.

Accessions. Analysis revealed significant differences on the total seed yield per plot of garden pea as affected by the different accessions (Table 5). It was noted that Chinese Light Green, CGP 13 and CGP 34 produced the highest total seed yield per plot with means of 383.50 g, 281.55 g and 280.63 g, respectively. This finding signifies that the accessions used have varying potential on seed yield per plot of the garden pea.

Interaction effect. A significant effect of interaction between inoculation and accession on the total seed yield per plot of garden peas was observed (Fig. 4). It was noted that uninoculated accessions attained both the highest and lowest seed yields while

Table 5. Total seed yield per plot (g) and total weight of 200 seeds per plot as affected by inoculation and garden pea accessions.

| | SEED YIELD PER PLOT ($g/5\ m^2$) | WEIGHT OF 200 SEEDS (g) |
|---|---|---|
| Inoculation (I) | | |
| Uninoculated | 235.380$^{b}$ | 30.88 |
| Inoculated | 251.29 $^{a}$ | 30.97 |
| Accessions (A) | | |
| CGP 13 | 281.55$^{a}$ | 36.72$^{a}$ |
| CGP 59 | 188.30 $^{c}$ | 29.18$^{c}$ |
| CGP 110 | 219.63 $^{b}$ | 29.28$^{c}$ |
| CGP 18A | 206.40 $^{c}$ | 34.27$^{b}$ |
| CGP 34 | 280.63 $^{a}$ | 29.00$^{c}$ |
| CLG | 283.50 $^{a}$ | 27.10$^{d}$ |
| I x A | 2.914 * | 1.093 $^{ns}$ |
| CV (a) % | 27.19 | 17.00 |
| CV (b) % | 26.20 | 10.73 |

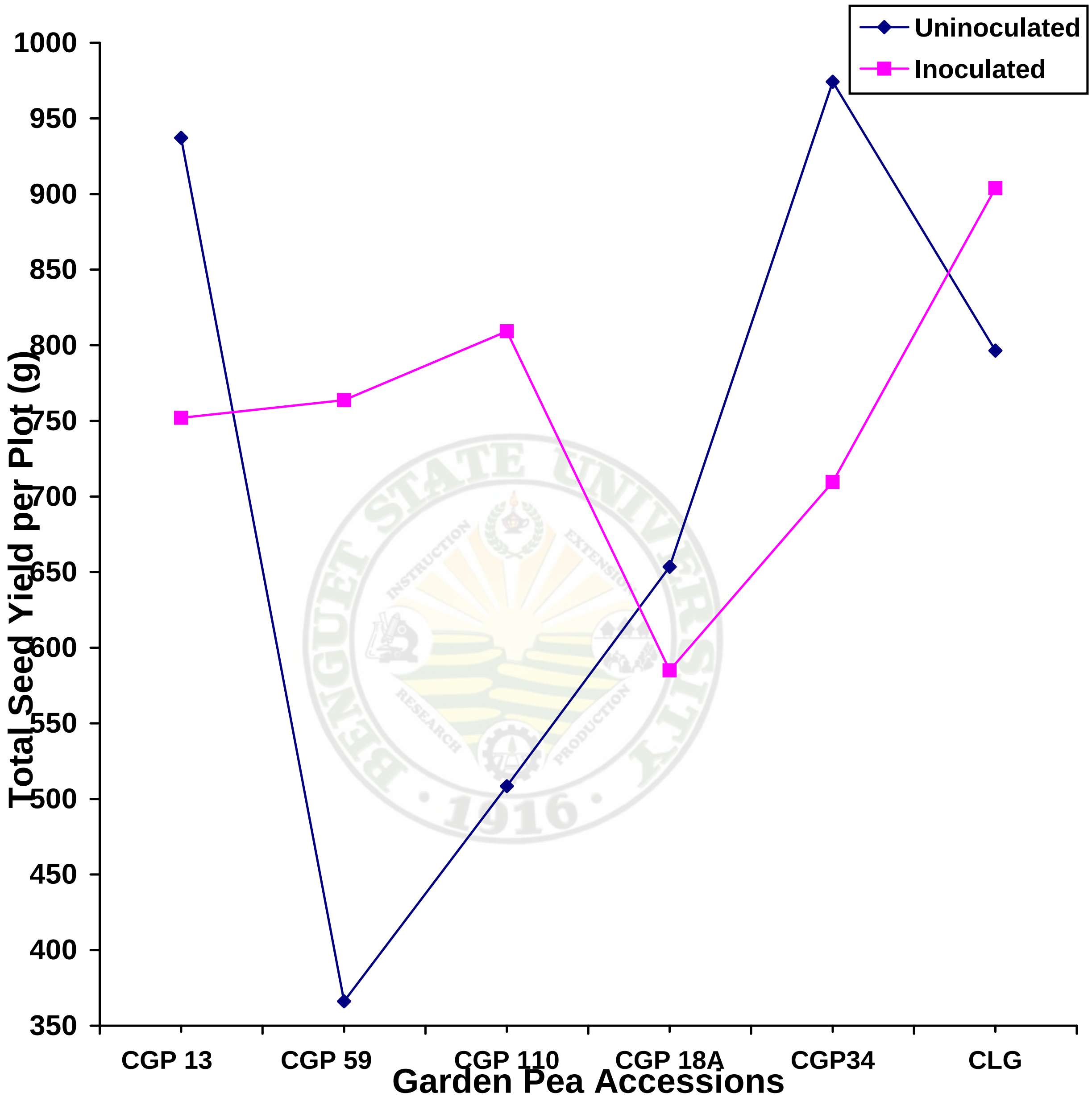



Figure 4. The interaction effect of inoculation and garden pea accessions on the total seed yield per plot.

the inoculated accessions yielded seeds on the average range. This result does not confirm with the finding on nodule count where CGP 34 had the highest nodule production.

Weight of 200 Seeds (g)

Inoculation. Table 5 shows no significant differences on the weight of 200 seeds of garden pea as affected by inoculation although the inoculated plants produced numerically heavier weight of 200seeds as compared to the uninoculated.

Accessions. Significant differences were noted_on the weight of 200 seeds of garden pea as affected by accession (Table 4). Results showed that CGP 13 produced a mean of 36.72 g on the weight of 200 seeds which was relatively higher than the other accessions this signifies that the weight of seeds of garden pea differ from one accession to the other this may due to their seed size. Based on the results, CGP 13 produced the heaviest of 200 seeds due to the bigger size of seed while Chinese light green produced the lightest had the smaller seed size.

Interaction effect. No significant interaction effect between the inoculation and accessions of garden pea in terms of the weight of 200 seed weight.

Return on Cash Expense (ROCE)

Inoculation. Table 6 show the result of return on cash expense (ROCE). Inoculated plants had the greater seed yield of 251g, with the high gross income of PhP 90.38 and a net income of PhP 9.36. Also it was noted that inoculated plants reveal the highest return on cash expense of 11.528%, compared to the uninoculated plants with a 8.313% ROCE. Results show that inoculation of seed increased seed yield of garden pea.

<u>Accession</u>. Among the different accessions CLG, CGP 34 and CGP 13 yielded seeds of 285.5 g, 282 g and 281 g respectively. The lowest seed yield was attained from CGP 59 of 188 g seed weight. Also it was noted that the same accessions attain the highest seed weight and highest return on cash expense of 28.74, 27.61 and 27.07. This is due to the high seed yield of production.

Table 6. Return on Cash Expenses of six garden pea accessions as affected by inoculation.

| TREATMENT | SEED YIELD (g) | VARIABLE COST (PhP) | GROSS INCOME (PhP) | NET INCOME (PhP) | ROCE % |
|---|---|---|---|---|---|
| Inoculation (I) | | | | | |
| Uninoculated | 236.33 | 78.39 | 84.91 | 6.17 | 8.313 |
| Inoculated | 251.5 | 81.18 | 90.38 | 9.36 | 11.53 |
| Accessions (A) | | | | | |
| CGP 13 | 281 | 79.785 | 101.16 | 21.375 | 27.07 |
| CGP 59 | 188 | 79.785 | 67.68 | -12.105 | -15.67 |
| CGP 110 | 220 | 79.785 | 79.24 | -0.565 | -1.075 |
| CGP 18A | 207 | 79.785 | 73.48 | -5.805 | -7.155 |
| CGP 34 | 282 | 79.785 | 112.5 | 21.735 | 27.61 |
| CLG | 285.5 | 79.785 | 102.78 | 22.995 | 28.74 |

Variable costs include labor cost, seeds, pesticide, stick, inoculant and twines.
Selling price were based at PhP 360.00 / kilo

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS


Summary

Effect of Inoculation

The effect of inoculation and six accessions of garden pea were studied under open field condition. The six accessions were CGP 13, CGP 59, CGP 110, CGP 18A, CGP 34 and CLG while the two accessions were inoculated and uninoculated.

Findings revealed that the effect of inoculation on some parameters did not differ significantly. Specifically, analysis revealed that the number of days from sowing to emergence, from emergence to flowering, from flowering to pod setting, from pod setting to first harvesting of garden pea as affected by inoculation were not significantly different from each other.

Also analysis revealed no significant differences on the nodule count, nodule fresh weight and nodule dry weight of nodules for both inoculated and uninoculated garden pea. Soil pH and soil nitrogen generally slightly increased after harvest but differences among the treatments were not substantial.

In terms of leaf miner and powdery mildew reaction of garden pea, inoculation had no significant influences.

Findings also revealed no significant differences on the weight of 200 seeds of garden pea. However, it was noted that there is significant on the total seed yield per plot as affected by inoculation.

Effect of Accession

On the days from sowing to emergence majority of the accessions emerged in 7 days except for CGP 59 and CGP 34 which emerged a day later. Almost similar was trend observed on days from emergence to flowering where CGP 18A and CGP 13 were the first to produce flower. On the other hand CLG and CGP 110 produced pods earlier at a days from flowering. From pod setting to harvesting of garden pea seeds, only slight differences were noted.

Significant differences were observed on the nodule count of garden pea as affected by the different accessions with CGP 34 producing the highest number of nodules.

CLG, CGP 13 and CGP 34 appear to produce the highest total seed yield per plot but they were not statistically different from the rest.

For the interaction, majority of the parameters were not significantly different from each other. However, highly significant effect of interaction between inoculation and accession on the total seed yield per plot of garden pea was observed.

Conclusion

Inoculation of seed before planting helps to enhance more nodules and give high seed yield of garden pea. CGP 34, CLG and CGP 13 were the best accessions that respond to inoculation in terms of nodulation and seed yield. Significant interaction observed on the total seed yield per plot. Inoculation noted to have the highest return on cash expenses of 28.72, 27.61 and 27.07.

Recommendation

Based on the results of the study, inoculation is effective under open field condition. Application of proper inoculant to seed before planting is recommended to obtain higher yield.

## LITERATURE CITED

ALEXANDER, M. 1977. Introduction to Soil Microbiology. 2nd ed. New York: John Willy and Sons. Inc. Pp. 315-322.

BISHOP, D.D., L.P. CARTER; S. R. CHAMPMAN and W.F BARBETT. 1983. Crop Science and food production. New York: McGraw-Hill Book Co. Pp.39-41

BRADY, N.C. 1985. Nature and Properties of Soils. 8th Ed. New York: McMillan Pub.Co. Pp. 39-41

BUENA C.G. 2004. Seed production of garden pea (*Pisum sativum*) applied with dolomite and coconut coir dust. BS Thesis. Benguet State University, La Trinidad, Benguet. Pp. 1-2

DEVLIN, R. M. and F.H WITHAM. 1983. Plant Physiology. 4th ed. Boston: Prindle, Weber and Schimidt. Pp. 157-162

HIGHLAND AGRICULTURE RESEARCH DEVELOPMENT CONSORTIUM (HARRDEC) 1996. Highland Garden Pea Techno guide. Benguet State University. La Trinidad, Benguet. Pp. 2,3

HILL, M. S 1994. Inoculation and Coating of Grass and Legumes Seeds. Seed Technology Center (Massey University Palmeston North, New Zealand) 1 (1):2-5

JENSEN. E. S 1989. Role of pea cultivation in the nitrogen economy of soils and succeeding crops in legumes in farming system (P. Plaquartand R, Hagar, Eds). Kluwer, Dordrecht. Pp. 3,15

MANGUIAT. T.J. P.M. MENDOZA and S.N. TILO 1985. Influence of the legumes Rhizobia symbiosis on the economy of legumes based cropping system. Phil. Agric. Jour 6: Pp.44-45

PADUA, D.P. 1997. The role of plant-rhizobial genotypes in biological nitrogen fixation in common bean (*Phaseolus vulgaris* L.) PhD. Dissertation. University of Gent, Gent Belgium. Pp. 26-27

PASCUA M.D. 1996. Nodulation and nitrogen fixation of two snap bean varieties as affected by different rhizobial strain, BS Thesis. La Trinidad, Benguet. Pp. 11-12, 14-15,38

PUYONGAN B. A. 1997. evaluation of different rhizobial strain for Biological nitrogen fixation ability in two varieties of snap bean.BS Thesis. Benguet State University, La Trinidad, Benguet. Pp. 5, 20, 40,41

RAMOS, R.B. 1991. Compatibility of different rhizobial strains to the three snap bean varieties. BS Thesis. Benguet State University, La Trinidad, Benguet Pp. 5,11

TALUSIG, A. T. 1996. Potential of snap bean entries for biological nitrogen fixation. BS Thesis. Benguet State University. La Trinidad, Benguet. Pp 4, 27, 40

TIPAYNO, M.T. 2006. Organic characters of five bush snap bean varieties inoculated with BIO N and VITAL N. BS Thesis. Benguet State University. La Trinidad, Benguet. P.4.

## APPENDICES

Appendix 1. Days from sowing to emergence

| TREATMENT | REPLICATION I | II | II | TOTAL | MEAN |
|---|---|---|---|---|---|
| UN INOCULATED | | | | | |
| CGP 13 | 7 | 7 | 7 | 21 | 7 |
| CGP 59 | 8 | 8 | 8 | 24 | 8 |
| CGP 110 | 7 | 7 | 7 | 21 | 7 |
| CGP 18A | 7 | 8 | 7 | 22 | 7 |
| CGP34 | 8 | 8 | 8 | 24 | 8 |
| CLG | 7 | 7 | 7 | 21 | 7 |
| SUB-TOTAL | 44 | 45 | 44 | 133 | 7 |
| INOCULATED | | | | | |
| CGP 13 | 7 | 7 | 7 | 21 | 7 |
| CGP 59 | 8 | 8 | 8 | 24 | 8 |
| CGP 110 | 7 | 7 | 7 | 21 | 7 |
| CGP 18A | 7 | 7 | 7 | 21 | 7 |
| CGP34 | 8 | 8 | 8 | 24 | 8 |
| CLG | 7 | 7 | 7 | 21 | 7 |
| SUB-TOTAL | 44 | 44 | 44 | 132 | 7 |
| TOTAL | 88 | 89 | 88 | 265 | 2.44 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS UNINOCULATED | INOCULATED | TOTAL | MEAN |
|---|---|---|---|---|
| C GP 13 | 21 | 21 | 42 | 2.33 |
| CGP 59 | 24 | 24 | 48 | 2.66 |
| CGP 110 | 21 | 21 | 42 | 2.33 |
| CGP 18A | 21 | 21 | 42 | 2.33 |
| CGP34 | 24 | 24 | 48 | 2.66 |
| CLG | 21 | 21 | 42 | 2.33 |
| TOTAL | 132 | 132 | 264 | |
| MEAN | 22 | 22 | | 2.44 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.889 | 0.444 | $0.571^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.028 | 0.028 | $0.036^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 1.556 | 0.778 | | | |
| Sub – plot (B) | 5 | 11.806 | 2.361 | $13.281^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 0.472 | 0.094 | $0.531^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 3.556 | 0.178 | | | |
| TOTAL | 35 | 18.306 | | | | |

ns – not significant

** - highly significant

CV (a) = 12.60%

CV (b) = 6.03%

Appendix 2. Days from emergence to first flowering.

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | II | | |
| UNINOCULATED | | | | | |
| CGP 13 | 37 | 37 | 37 | 111 | 37 |
| CGP 59 | 44 | 44 | 44 | 132 | 44 |
| CGP 110 | 45 | 45 | 45 | 135 | 45 |
| CGP 18A | 39 | 39 | 38 | 116 | 38 |
| CGP34 | 48 | 48 | 48 | 143 | 48 |
| CLG | 43 | 42 | 43 | 128 | 43 |
| SUB-TOTAL | 256 | 255 | 255 | 765 | 42.5 |
| INOCULATED | | | | | |
| CGP 13 | 37 | 37 | 37 | 111 | 37 |
| CGP 59 | 44 | 44 | 44 | 132 | 44 |
| CGP 110 | 45 | 45 | 45 | 135 | 45 |
| CGP 18A | 39 | 39 | 39 | 117 | 39 |
| CGP34 | 48 | 48 | 48 | 143 | 48 |
| CLG | 43 | 42 | 43 | 128 | 43 |
| SUB-TOTAL | 256 | 255 | 256 | 766 | 42.56 |
| TOTAL | 512 | 510 | 511 | 1533 | 14.18 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | TOTAL | MEAN |
|---|---|---|---|---|
| | UNINOCULATED | INOCULATED | | |
| CGP 13 | 111 | 111 | 222 | 12.34 |
| CGP 59 | 132 | 132 | 264 | 14.67 |
| CGP 110 | 135 | 135 | 270 | 15 |
| CGP 18A | 116 | 117 | 233 | 12.94 |
| CGP34 | 143 | 143 | 286 | 15.89 |
| CLG | 128 | 128 | 256 | 14.22 |
| TOTAL | 765 | 766 | 1531 | |
| MEAN | 42.5 | 42.56 | | 14.18 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.722 | 0.361 | 0.265[ns] | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.111 | 0.111 | 0.082[ns] | 18.51 | 98.41 |
| Error (a) | 2 | 2.722 | 1.361 | | | |
| Sub – plot (B) | 5 | 509.889 | 101.978 | 524.457** | 2.71 | 4.10 |
| AxB | 5 | 0.889 | 0.178 | 0.914[ns] | 2.71 | 4.10 |
| Error (b) | 20 | 3.889 | 0.194 | | | |
| TOTAL | 35 | 518.222 | | | | |

ns – not significant　　CV (a) = 2.78%

** - highly significant　　CV (b) = 1.05%

Appendix 3. Days from flowering to pod setting

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | |
| Uninoculated | | | | | |
| CGP 13 | 13 | 14 | 14 | 41 | 14 |
| CGP 59 | 10 | 10 | 10 | 30 | 10 |
| CGP 110 | 9 | 9 | 10 | 28 | 9 |
| CGP 18A | 12 | 12 | 12 | 36 | 12 |
| CGP34 | 17 | 17 | 17 | 51 | 17 |
| CLG | 9 | 8 | 9 | 26 | 9 |
| SUB-TOTAL | 70 | 70 | 72 | 212 | 12 |
| INOCULATED | | | | | |
| CGP 13 | 13 | 14 | 14 | 41 | 14 |
| CGP 59 | 10 | 10 | 10 | 30 | 10 |
| CGP 110 | 9 | 9 | 10 | 28 | 9 |
| CGP 18A | 12 | 12 | 12 | 36 | 12 |
| CGP34 | 17 | 17 | 17 | 51 | 17 |
| CLG | 9 | 8 | 9 | 26 | 9 |
| SUB-TOTAL | 70 | 70 | 72 | 212 | 12 |
| TOTAL | 140 | 140 | 144 | 424 | 4 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | TOTAL | MEAN |
|---|---|---|---|---|
| | UNINOCULATED | INOCULATED | | |
| CGP 13 | 41 | 41 | 82 | 5 |
| CGP 59 | 30 | 30 | 60 | 3 |
| CGP 110 | 28 | 28 | 56 | 3 |
| CGP 18A | 36 | 36 | 72 | 4 |
| CGP34 | 51 | 51 | 102 | 6 |
| CLG | 26 | 26 | 52 | 3 |
| TOTAL | 212 | 212 | 424 | |
| MEAN | 12 | 12 | | 4 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 2.167 | 1.083 | 13.00$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.250 | 0.250 | 3.00$^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 0.167 | 0.083 | | | |
| Sub – plot (B) | 5 | 287.917 | 57.583 | 314.091$^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 0.583 | 0.117 | 0.636$^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 3.667 | 0.183 | | | |
| TOTAL | 35 | 294.750 | | | | |

ns – not significant CV (a) = 2.40%

** - highly significant CV (b) = 3.56%

Table 4. Days from pod setting to first harvest

| TREATMENT | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| UNINOCULATED | | | | | |
| CGP 13 | 37 | 37 | 37 | 111 | 37 |
| CGP 59 | 35 | 35 | 35 | 105 | 35 |
| CGP 110 | 35 | 35 | 35 | 105 | 35 |
| CGP 18A | 37 | 37 | 37 | 111 | 37 |
| CGP34 | 41 | 41 | 41 | 123 | 41 |
| CLG | 36 | 36 | 36 | 108 | 36 |
| SUB-TOTAL | 221 | 221 | 221 | 663 | 37 |
| INOCULATED | | | | | |
| CGP 13 | 37 | 37 | 37 | 111 | 37 |
| CGP 59 | 35 | 35 | 35 | 105 | 35 |
| CGP 110 | 35 | 35 | 35 | 105 | 35 |
| CGP 18A | 37 | 37 | 37 | 111 | 37 |
| CGP34 | 41 | 41 | 41 | 123 | 41 |
| CLG | 36 | 36 | 36 | 108 | 36 |
| SUB-TOTAL | 221 | 221 | 221 | 663 | 37 |
| TOTAL | 442 | 442 | 442 | 1226 | 12 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS UNINOCULATED | INOCULATED | TOTAL | MEAN |
|---|---|---|---|---|
| CGP 13 | 111 | 111 | 222 | 12 |
| CGP 59 | 105 | 105 | 210 | 12 |
| CGP 110 | 105 | 105 | 210 | 12 |
| CGP 18A | 111 | 111 | 222 | 12 |
| CGP34 | 123 | 123 | 246 | 14 |
| CLG | 108 | 108 | 116 | 6 |
| TOTAL | 663 | 663 | 1226 | |
| MEAN | 37 | 37 | | 12 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.167 | 0.083 | 3.00$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.028 | 0.028 | 1.00$^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 0.056 | 0.028 | | | |
| Sub – plot (B) | 5 | 469.250 | 93.850 | 1689.30$^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 0.139 | 0.028 | 0.50$^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 1.111 | 0.056 | | | |
| TOTAL | 35 | 470.750 | | | | |

ns – not significant CV (a) = 0.35%

** - highly significant CV (b) = 0.49%

Appendix 5. Nodule count at 40 DAP

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | B I | B II | B II | | |
| UNINOCULATED | | | | | |
| CGP 13 | 132 | 120 | 132 | 384 | 128 |
| CGP 59 | 129 | 137 | 129 | 395 | 131.67 |
| CGP 110 | 123 | 134 | 131 | 388 | 139.33 |
| CGP 18A | 159 | 120 | 114 | 393 | 131 |
| CGP34 | 157 | 163 | 136 | 456 | 152 |
| CLG | 124 | 139 | 150 | 413 | 137.67 |
| SUB-TOTAL | 824 | 813 | 792 | 2429 | 136.61 |
| INOCULATED | | | | | |
| CGP 13 | 183 | 155 | 144 | 482 | 160.67 |
| CGP 59 | 166 | 165 | 166 | 497 | 165.67 |
| CGP 110 | 161 | 169 | 164 | 494 | 164.67 |
| CGP 18A | 165 | 144 | 122 | 431 | 143.67 |
| CGP34 | 199 | 185 | 178 | 562 | 187.33 |
| CLG | 169 | 174 | 169 | 512 | 170.67 |
| SUB-TOTAL | 1043 | 992 | 943 | 2978 | 165.45 |
| TOTAL | 1867 | 1805 | 1735 | 5407 | 50.34 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | | |
|---|---|---|---|---|
| | UNINOCULATED | INOCULATED | TOTAL | MEAN |
| CGP 13 | 384 | 482 | 866 | 48.11 |
| CGP 59 | 395 | 497 | 892 | 49.56 |
| CGP 110 | 388 | 494 | 882 | 49 |
| CGP 18A | 393 | 431 | 824 | 45.79 |
| CGP34 | 456 | 562 | 1018 | 56.57 |
| CLG | 413 | 512 | 925 | 51.39 |
| TOTAL | 24.29 | 27.78 | 54.07 | |
| MEAN | 134.95 | 165.45 | | 50.35 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 726.889 | 363.444 | 3.734$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 8372.250 | 8372.250 | 86.016$^{*}$ | 18.51 | 98.41 |
| Error (a) | 2 | 194.667 | 97.333 | | | |
| Sub – plot (B) | 5 | 3643.472 | 728.694 | 4.511$^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 581.917 | 116.383 | 0.721$^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 3230.444 | 161.522 | | | |
| TOTAL | 35 | 16749.639 | | | | |

ns – not significant

** - highly significant

* - significant

CV (a) = 6.58%

CV (b) = 8.47%

Appendix 6. Nodule fresh weight at 40 DAP

| TREATMENT | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| UNINOCULATED | | | | | |
| CGP 13 | 0.43 | 0.34 | 0.65 | 1.42 | 0.47 |
| CGP 59 | 0.55 | 0.46 | 0.56 | 1.57 | 0.52 |
| CGP 110 | 0.2 | 0.48 | 0.56 | 1.24 | 0.41 |
| CGP 18A | 0.63 | 0.3 | 0.43 | 1.36 | 0.45 |
| CGP34 | 0.56 | 0.95 | 0.68 | 2.19 | 0.73 |
| CLG | 0.48 | 0.45 | 0.49 | 1.42 | 0.47 |
| SUB-TOTAL | 2.85 | 2.98 | 3.37 | 9.2 | 0.16 |
| INOCULATED | | | | | |
| CGP 13 | 0.56 | 0.64 | 0.49 | 1.69 | 0.56 |
| CGP 59 | 0.45 | 0.27 | 0.51 | 1.23 | 0.41 |
| CGP 110 | 0.52 | 0.66 | 0.7 | 1.88 | 0.63 |
| CGP 18A | 1.58 | 0.49 | 0.77 | 2.84 | 0.95 |
| CGP34 | 0.79 | 1.16 | 0.91 | 2.86 | 0.95 |
| CLG | 0.68 | 0.66 | 0.78 | 2.12 | 0.71 |
| SUB-TOTAL | 4.58 | 3.88 | 4.16 | 12.62 | 0.23 |
| TOTAL | 7.43 | 6.86 | 7.53 | 21.82 | 0.07 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS UNINOCULATED | INOCULATED | TOTAL | MEAN |
|---|---|---|---|---|
| CGP 13 | 1.42 | 1.69 | 3.11 | 0.17 |
| CGP 59 | 1.57 | 1.23 | 2.8 | 0.16 |
| CGP 110 | 1.24 | 1.88 | 3.12 | 0.17 |
| CGP 18A | 1.36 | 2.84 | 4.2 | 0.23 |
| CGP34 | 2.19 | 2.86 | 5.05 | 0.28 |
| CLG | 1.42 | 2.12 | 3.54 | 0.21 |
| TOTAL | 9.2 | 12.62 | 21.82 | |
| MEAN | 0.16 | 0.23 | | 0.07 |

\

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.022 | 0.011 | $0.495^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.325 | 0.325 | $14.763^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 0.044 | 0.022 | | | |
| Sub – plot (B) | 5 | 0.595 | 0.119 | $2.429^{ns}$ | 2.71 | 4.10 |
| AxB | 5 | 0.296 | 0.059 | $1.210^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 0.979 | 0.049 | | | |
| TOTAL | 35 | 2.261 | | | | |

ns – not significant

CV (a) = 24.32%

CV (b) = 36.29%

Appendix 7. Nodule dry weight at 40 DAP

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | II | | |
| UNINOCULATED | | | | | |
| CGP 13 | 0.19 | 0.2 | 0.26 | 0.65 | 0.22 |
| CGP 59 | 0.35 | 0.49 | 0.24 | 1.08 | 0.36 |
| CGP 110 | 0.12 | 0.28 | 0.21 | 0.61 | 0.20 |
| CGP 18A | 0.28 | 0.14 | 0.28 | 0.7 | 0.23 |
| CGP34 | 0.32 | 0.6 | 0.2 | 1.12 | 0.37 |
| CLG | 0.18 | 0.16 | 0.2 | 0.54 | 0.18 |
| SUB-TOTAL | 1.44 | 1.87 | 1.39 | 4.7 | 0.26 |
| INOCULATED | | | | | |
| CGP 13 | 0.41 | 0.32 | 0.16 | 0.89 | 0.30 |
| CGP 59 | 0.28 | 0.13 | 0.21 | 0.65 | 0.22 |
| CGP 110 | 0.28 | 0.3 | 0.24 | 0.82 | 0.27 |
| CGP 18A | 0.55 | 0.28 | 0.42 | 1.25 | 0.42 |
| CGP34 | 0.23 | 0.41 | 0.28 | 0.92 | 0.31 |
| CLG | 0.26 | 0.25 | 0.31 | 0.82 | 0.27 |
| SUB-TOTAL | 2.01 | 1.69 | 1.62 | 5.35 | 0.30 |
| TOTAL | 3.45 | 3.56 | 3.01 | 10.06 | 0.09 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | TOTAL | MEAN |
|---|---|---|---|---|
| | UNINOCULATED | INOCULATED | | |
| CGP 13 | 0.65 | 0.89 | 1.54 | 0.09 |
| CGP 59 | 1.08 | 0.65 | 1.73 | 0.10 |
| CGP 110 | 0.61 | 0.82 | 1.43 | 0.08 |
| CGP 18A | 0.7 | 1.25 | 1.96 | 0.11 |
| CGP34 | 1.12 | 0.92 | 2.04 | 0.11 |
| CLG | 0.54 | 0.82 | 1.36 | 0.08 |
| TOTAL | 4.7 | 5.35 | 10.06 | |
| MEAN | 0.26 | 0.30 | | 0.09 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.015 | 0.008 | 0.706[ns] | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.012 | 0.012 | 1.086[ns] | 18.51 | 98.41 |
| Error (a) | 2 | 0.022 | 0.011 | | | |
| Sub – plot (B) | 5 | 0.065 | 0.013 | 1.264[ns] | 2.71 | 4.10 |
| AxB | 5 | 0.106 | 0.210 | 2.068[ns] | 2.71 | 4.10 |
| Error (b) | 20 | 0.205 | 0.010 | | | |
| TOTAL | 35 | 0.425 | | | | |

ns – not significant

CV (a) = 37.46%

CV (b) = 35.71%

Appendix 8. Resistance to leaf miner

| TREATMENT | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| UNINOCULATED | | | | | |
| CGP 13 | 3 | 3 | 3 | 9 | 3 |
| CGP 59 | 3 | 3 | 2 | 8 | 2 |
| CGP 110 | 2 | 2 | 3 | 7 | 2 |
| CGP 18A | 3 | 3 | 2 | 8 | 3 |
| CGP34 | 3 | 3 | 3 | 9 | 3 |
| CLG | 2 | 2 | 2 | 6 | 2 |
| SUB-TOTAL | 16 | 16 | 15 | 47 | 2 |
| INOCULATED | | | | | |
| CGP 13 | 3 | 3 | 3 | 9 | 3 |
| CGP 59 | 3 | 3 | 2 | 8 | 3 |
| CGP 110 | 2 | 2 | 3 | 7 | 2 |
| CGP 18A | 3 | 3 | 2 | 8 | 3 |
| CGP34 | 3 | 3 | 3 | 9 | 3 |
| CLG | 2 | 2 | 2 | 6 | 2 |
| SUB-TOTAL | 16 | 16 | 15 | 47 | 3 |
| TOTAL | 32 | 32 | 30 | 94 | 1 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS UNINOCULATED | INOCULATED | TOTAL | MEAN |
|---|---|---|---|---|
| CGP 13 | 9 | 9 | 18 | 1 |
| CGP 59 | 8 | 8 | 16 | 0.89 |
| CGP 110 | 7 | 7 | 14 | 0.78 |
| CGP 18A | 8 | 8 | 16 | 0.89 |
| CGP34 | 9 | 9 | 18 | 1 |
| CLG | 6 | 6 | 12 | 0.67 |
| TOTAL | 47 | 47 | 94 | |
| MEAN | 2 | 3 | | 1 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.167 | 0.083 | 1.000$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.250 | 0.250 | 3.000$^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 0.167 | 0.083 | | | |
| Sub – plot (B) | 5 | 3.583 | 0.717 | 3.909$^{*}$ | 2.71 | 4.10 |
| AxB | 5 | 0.917 | 0.183 | 1.000$^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 3.667 | 0.183 | | | |
| TOTAL | 35 | 8.750 | | | | |

ns – not significant CV (a) = 14.40%

* - significant CV (b) = 21.39%

Appendix 9. Resistance to powdery mildew

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
| --- | --- | --- | --- | --- | --- |
| | I | II | III | | |
| UNINOCULATED | | | | | |
| CGP 13 | 3 | 3 | 3 | 9 | 3 |
| CGP 59 | 3 | 3 | 3 | 9 | 3 |
| CGP 110 | 2 | 2 | 2 | 6 | 2 |
| CGP 18A | 2 | 3 | 2 | 7 | 3 |
| CGP34 | 3 | 3 | 3 | 9 | 3 |
| CLG | 2 | 2 | 2 | 6 | 2 |
| SUB-TOTAL | 15 | 16 | 15 | 46 | 3 |
| INOCULATED | | | | | |
| CGP 13 | 3 | 3 | 3 | 9 | 3 |
| CGP 59 | 3 | 3 | 3 | 9 | 3 |
| CGP 110 | 2 | 2 | 2 | 6 | 2 |
| CGP 18A | 2 | 3 | 2 | 7 | 3 |
| CGP34 | 3 | 3 | 3 | 9 | 3 |
| CLG | 2 | 2 | 2 | 6 | 2 |
| SUB-TOTAL | 15 | 16 | 15 | 46 | 3 |
| TOTAL | 30 | 32 | 30 | 92 | 1 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | TOTAL | MEAN |
| --- | --- | --- | --- | --- |
| | UNINOCULATED | INOCULATED | | |
| CGP 13 | 9 | 9 | 18 | 9 |
| CGP 59 | 9 | 9 | 18 | 9 |
| CGP 110 | 6 | 6 | 12 | 6 |
| CGP 18A | 7 | 7 | 14 | 7 |
| CGP34 | 9 | 9 | 18 | 9 |
| CLG | 6 | 6 | 12 | 6 |
| TOTAL | 46 | 46 | 92 | |
| MEAN | 3 | 3 | | 1 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 0.389 | 0.194 | 7.000$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.028 | 0.028 | 1.000$^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 0.056 | 0.028 | | | |
| Sub – plot (B) | 5 | 6.806 | 1.361 | 17.500$^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 0.139 | 0.028 | 0.357$^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 1.553 | 0.078 | | | |
| TOTAL | 35 | 8.972 | | | | |

ns – not significant CV (a) = 5.58%

** - highly significant CV (b) = 9.31%

Appendix 10. Total seed yield per plot (g)

| TREATMENT | REPLICATION I | II | III | TOTAL | MEAN |
|---|---|---|---|---|---|
| UNINOCULATED | | | | | |
| CGP 13 | 362.8 | 210 | 364.4 | 937.2 | 312.4 |
| CGP 59 | 110.2 | 138.4 | 117.5 | 366.1 | 122.03 |
| CGP 110 | 189.2 | 125.8 | 193.5 | 508.5 | 169.5 |
| CGP 18A | 218.3 | 177 | 258.2 | 653.5 | 217.83 |
| CGP34 | 204.2 | 289.5 | 480.6 | 974.3 | 324.77 |
| CLG | 293 | 146.2 | 357.3 | 796.5 | 265.5 |
| SUB-TOTAL | 1377.7 | 1086.9 | 1771.5 | 4236.1 | 235.34 |
| INOCULATED | | | | | |
| CGP 13 | 215.7 | 204.4 | 332 | 752.1 | 250.70 |
| CGP 59 | 123.7 | 315.2 | 324.8 | 763.7 | 254.57 |
| CGP 110 | 288.7 | 227.6 | 293 | 809.3 | 269.77 |
| CGP 18A | 122.5 | 239.1 | 223.3 | 584.9 | 194.97 |
| CGP34 | 192.5 | 223.3 | 293.7 | 709.5 | 236.5 |
| CLG | 320.5 | 217.1 | 366.2 | 903.8 | 301.27 |
| SUB-TOTAL | 1263.6 | 1426.7 | 1833 | 4523.3 | 251.30 |
| TOTAL | 2641.3 | 2513.6 | 3604.5 | 8759.4 | 81.11 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS UNINOCULATED | INOCULATED | TOTAL | MEAN |
|---|---|---|---|---|
| CGP 13 | 937.2 | 752.1 | 1689.3 | 93.85 |
| CGP 59 | 366.1 | 763.7 | 1129.8 | 62.77 |
| CGP 110 | 508.5 | 809.3 | 1317.8 | 73.21 |
| CGP 18A | 653.5 | 584.9 | 1238.4 | 68.8 |
| CGP34 | 974.3 | 709.5 | 1683.8 | 93.54 |
| CLG | 796.5 | 903.8 | 1700.3 | 94.46 |
| TOTAL | 4236.1 | 4523.3 | 8759.4 | |
| MEAN | 235.5 | 251.30 | | 81.11 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 59248.767 | 29624.384 | 6.767$^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 2280.063 | 2280.063 | 0.521$^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 8755.382 | 4377.691 | | | |
| Sub – plot (B) | 5 | 56517.561 | 11303.512 | 2.781$^{*}$ | 2.71 | 4.10 |
| AxB | 5 | 59222.766 | 1184.553 | 2.914$^{*}$ | 2.71 | 4.10 |
| Error (b) | 20 | 81288.124 | 4064.406 | | | |
| TOTAL | 35 | 267312.663 | | | | |

ns – not significant CV (a) = 27.19%

* - significant CV (b) = 26.20%

Appendix 11. Total weight of 200 seeds (g)

| TREATMENT | REPLICATION | | | TOTAL | MEAN |
|---|---|---|---|---|---|
| | I | II | III | | |
| UNINOCULATED | | | | | |
| CGP 13 | 34.9 | 32.7 | 36.1 | 103.7 | 34.57 |
| CGP 59 | 25.7 | 29.7 | 31.6 | 87 | 29 |
| CGP 110 | 32.3 | 33.4 | 24.9 | 90.6 | 30.2 |
| CGP 18A | 37.00 | 35.6 | 35.7 | 108.3 | 36.1 |
| CGP34 | 28.4 | 28.2 | 31.4 | 88 | 29.33 |
| CLG | 28.1 | 24.2 | 25.9 | 78.2 | 26.07 |
| SUB-TOTAL | 186.4 | 183.8 | 185.6 | 555.8 | 30.88 |
| INOCULATED | | | | | |
| CGP 13 | 46.3 | 33.00 | 37.3 | 116.6 | 38.87 |
| CGP 59 | 27.1 | 28.6 | 32.4 | 88.1 | 29.37 |
| CGP 110 | 31.4 | 26.2 | 27.5 | 85.1 | 28.37 |
| CGP 18A | 33.4 | 31.4 | 32.5 | 97.3 | 32.43 |
| CGP34 | 31.7 | 25.1 | 29.2 | 86 | 28.67 |
| CLG | 37 | 24.3 | 23.1 | 84.4 | 28.13 |
| SUB-TOTAL | 206.9 | 168.6 | 182 | 557.7 | 30.97 |
| TOTAL | 393.3 | 352.4 | 367.6 | 1113.5 | 10.31 |

TWO WAY TABLE

| TREATMENT | GARDEN PEA ACCESSIONS | | | |
|---|---|---|---|---|
| | UNINOCULATED | INOCULATED | TOTAL | MEAN |
| CGP 13 | 103.7 | 116.6 | 220.3 | 12.24 |
| CGP 59 | 87 | 88.1 | 175.1 | 9.73 |
| CGP 110 | 90.6 | 85.1 | 175.7 | 9.75 |
| CGP 18A | 108.3 | 97.3 | 205.6 | 11.42 |
| CGP34 | 88 | 86 | 174 | 9.67 |
| CLG | 78.2 | 84.4 | 162.6 | 9.03 |
| TOTAL | 555.8 | 557.7 | 1113.5 | |
| MEAN | 30.88 | 30.97 | | 10.31 |

ANALYSIS OF VARIANCE

| SOURCE OF VARIATION | DEGREE OF FREEDOM | SUM OF SQUARES | MEAN OF SQUARES | COMPUTED F | TABULATED F | |
|---|---|---|---|---|---|---|
| | | | | | .05 | .01 |
| Replication | 2 | 71.232 | 35.616 | $1.289^{ns}$ | 19.00 | 99.00 |
| Main plot (A) | 1 | 0.080 | 0.080 | $0.003^{ns}$ | 18.51 | 98.41 |
| Error (a) | 2 | 55.274 | 27.637 | | | |
| Sub – plot (B) | 5 | 412.649 | 82.530 | $7.497^{**}$ | 2.71 | 4.10 |
| AxB | 5 | 60.138 | 12.028 | $1.093^{ns}$ | 2.71 | 4.10 |
| Error (b) | 20 | 220.174 | 11.009 | | | |
| TOTAL | 35 | 819.548 | | | | |

ns – not significant

** - highly significant

CV (a) = 17%

CV (b) = 10.73%