Mass Selection of Snake Bean (*Vigna unguiculata* ssp. *sesquipedalis.* (L.) Verdc.) for Pod Length and Yield in Fourth Generation

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A thesis submitted in fulfillment of the requirement for the degree of Bachelor of Applied Science (Agrotechnology) with Honours

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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Student's Name: Zahrotul Jannah binti Azhar

Date:

I certify that the report of this final year project entitled "Mass Selection of Snake Bean (*Vigna unguiculata* ssp. *sesquipedalis.* (L.) Verdc.) cv MKP5 for Pod Length and Yield in Fourth Generation" by Zahrotul Jannah binti Azhar, matric number F15A0258 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agriculture Technology) with Honours,

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Date:

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ABSTRACT

Snake bean (*Vigna unguiculata* ssp *sesquipedalis* L.) is one of important vegetables in tropical and subtropical region. The consumption of snake bean is high by increasing the human population growth in Malaysia. Snake bean is popular in Malaysia because of their distinctive and appetizing taste. Snake bean must be improved to increase the production to support the consumption. Mass selection can be used to increase yield in plants. Pod length is one of the main components of yield of snake bean. Therefore, this research is conducted to improve the yield by improving the pod length of snake bean by using mass selection technique. Two hundred and forty seeds were selected from previous generation. They were grown in eight plots. The pods longer than 75cm were selected and dried for next generation (fifth generation). From this research, the mean of pod length was 54.31 cm which is lower than third generation (56.17cm) due to some unfavorable condition. Meanwhile, the yield for the fourth generation was 169.9 kg higher than third generation (161.0 kg).

Keywords: Snake bean, mass selection, pod length, yield, generation

Seleksi Pukal Kacang panjang (*Vigna unguiculata* ssp. *sesquipedalis.* (L.) Verdc.) cv MKP5 untuk Panjang Pod dan Hasil dalam Generasi Keempat

ABSTRAK

Kacang Panjang (Vigna unguiculata ssp sesquipedalis L.) adalah salah satu sayuran penting di rantau tropika dan subtropika. Pengambilan kacang panjang adalah tinggi setara dengan meningkatnya pertumbuhan populasi manusia di Malaysia. Kacang panjang popular di Malaysia kerana rasanya menyelerakan dan tersendiri. Kacang Panjang mesti ditambah baik dengan meningkatkan pengeluarannya untuk menampung pengambilannya. Seleksi pukal boleh digunakan untuk meningkatkan hasil tumbuhan yang lebih tinggi. Panjang pod adalah salah satu komponen utama hasil kacang panjang. Oleh itu, kajian ini dijalankan untuk meningkatkan hasil dengan menambah baik panjang pod kacang panjang melalui seleksi pukal. Dua ratus empat puluh biji benih telah dipilih dari generasi terdahulu. Biji benih ditanam di lapan plot. Pod kacang panjang yang lebih daripada 75cm dipilih dan dikeringkan untuk kegunaan generasi akan datang (generasi kelima). Daripada kajian ini, purata panjang pod ialah 54.31 cm yang lebih rendah daripada generasi ketiga (56.17cm) disebabkan oleh beberapa keadaan yang tidak menguntungkan. Sementara itu, hasil bagi generasi keempat adalah 169.9 kg lebih tinggi daripada generasi ketiga (161.0 kg). Keterwarisan adalah -0.06.

Kata kunci: kacang panjang, seleksi pukal, panjang pod, hasil, generasi

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LIST OF ABBREVIATION AND SYMBOLS

cm	Centimeter
g	Gram
ha	Hectare
h^2	Narrow sense heritability
kg	Kilogram
m	Meter
mt	Metric ton
R	A measurement how much the mean has changed in one generation
S	Differences between the mean of selected parents and the mean of population
T_o	Mean of offspring
T_s	Mean of selected parents
μ	Mean of population

CHAPTER 1

INTRODUCTION

1.1 Background of study

Snake bean (*Vigna unguiculata* subsp. *sesquipedalis* L. (Verdc.) is from the Fabaceae family. It is accordingly a leguminous vegetable and mostly the snake bean is cultivated in China, Southeast Asia, the Carribean, Central and West Africa (FAO, 1993; Piluek, 1994). It is a common vegetable in Asian markets (Benchasri et al., 2012; Chanapan et al, 2017).

In Malaysia and Indonesia, snake bean is commonly known as "kacang panjang" and has been consumed by Malaysian as the nutrient local vegetable. Snake bean is popular in Malaysia because of their distinctive and appetizing taste (Rahman *et al.* 2013). It is often consumed as immature pods as a source of protein (24–27%) (Ano and Ubochi, 2008), vitamins, minerals and fibres (Messina, 1999).

The demands of snake beans are higher currently among Malaysian. Malaysia's population has been on a rapid growth, 32.4 million population in first quarter 2018; increase by 1.3 per cent compared to first quarter 2017 (DOS, 2018). As the population increases, the consumption of snake bean also increases. Although the demands increases, the production of main vegetables in the country decreased in 2015, 2016 and 2017 (Statistic, 2017)

Table 1.1: The total production of main vegetables in Malaysia (2013-2017) (Statistic, 2017)

Year	Production (mt)	Planted area (ha)
2013	1,326,504	63,030
2014	1,385,114	67,049
2015	1,322,526	65,997
2016	1,169,415	61,641
2017	973,660	60,510

From the table 1.1 above, it shows that the production of main vegetables in Malaysia is decreasing including snake bean. The production of snake bean in three years recently were 69,295 mt (2015), 63,473 mt (2016) and 58,808.03 mt (2017) (Statistic, 2015; Statistic, 2016; Statistic, 2017). Snake bean is mostly grown in Johor and Perak. The planted area of snake bean in 2017 were 5027.70 ha, larger area compared to year 2015 (4799 ha) and 2016 (4528 ha); but the production of snake bean in 2017 were the lowest (Statistic, 2015; Statistic, 2016; Statistic, 2017).

To overcome this problem, there are two ways in increasing the production of snake bean: extensification and intensification in agriculture. For extensification, the production can be increased by expanding land for cultivating snake bean (Nkamleu, 2011). There are many unutilized land especially in Kelantan that can be used for cultivating snake bean. While for intensification, more input and technology can be applied to increase the product of snake bean including the use of high yielding cultivars. Besides the vegetative growths for supporting the yield, the number of flowers, the number of pods and the lengths of pods are the important components of yield for snake bean. The good cultivar and high yield seeds are the best choice for practicing the sustainable intensification. Mass selection is one of the method of plant breeding for achieving the better cultivar of snake bean plant specially to improve the pod length.

Mass selection is the oldest selection method of plant breeding (Acquaah, 2007) and apparently the most used in plant breeding over years. It is a common and easy method of crop improvement. Mass selection is an example of selection from a biologically variable population in which differences are genetic in origin. Simple and economical are the main advantage of this method. Its efficiency depends on gene effects on selected trait, trait heritability, genotype × environment interaction, and sample size. Traits that are highly heritable and controlled by additive genes are more efficient (Miladinovic, 2007).

In many domestic crop species, mass selection was very important. The mass selection was based on visual selection of phenotypes (Abreu et al, 2010). This method has been found to increase yield in higher plants and improve the proportion of superior genotypes in a short time (Yang et al. 2013). The success in maize plant prove the mass selection method (Achmad, 1984). The grain colour, plant height, size of ear placement of ear on the stalk, date of maturity and percentage of oil and protein content were possible varieties to develop (Sutedjo, 1977). Besides, at the end of 19th century mass selection also contributed to the further spreading of sunflower and creation of a number of local varieties that were mostly grown in gardens. The first sunflower varieties were characterized by great variability, especially in vegetation cycle and seed traits. (Miladinovic, 2007). Thus, this mass selection method will be done to improve pod length of snake bean.

1.2 Problem Statement

In Malaysia, snake bean consumption becomes higher year by year. However, the production of snake bean in Malaysia does not enough to support the whole country. Snake bean imports persisted on an uptrend between 2010 and 2012, especially cheaper imports from Thailand and China (Madhavan, 2014). Thus, the production of snake bean in the country can be upgraded by mass selection. The improvement of pod length that will lead to increase the yield of snake bean. The improvement of pod length can be done by mass selection method.

1.3 Objective

The objective of this research is to select the longest pod length for improve yield of snake bean by mass selection in fourth generation and bulk the seed for next generation.

1.4 Scope of study

This research focused on the main objective to increase the pod length and yield through mass selection methods. The important part of this research is the pod length of snake bean. The higher demands of snake bean were overcome by this method. The data of plant growth is observed and calculated.

1.5 Significance of Study

In this research, the pod length of the snake bean can be improved. This is because the higher yield of snake bean depends on the length of pod length. This is important because it can produce new better phenotype as a new cultivar of snake bean. The better performance of seeds was selected for the high production of next generation. The seed selected was the longer pod length for the higher yield of production in next generation.

1.6 Limitation of study

This research is only can develop for one generation of snake bean. So, the longest period time are used for get the best result for this mass selection. Then, this mass selection method is target only in one phenotype which is pod length.

CHAPTER 2

LITERATURE REVIEW

2.1 Botany of *Vigna unguiculata*

Snake bean (*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc. is one of the important leguminous vegetable crops. Snake bean is in the same group with cowpea, grown as a vegetable crop (Madhu and Radha, 2008). The taxonomy of snake bean according to Cronquist (1981) is:

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Rosidae

Order: Fabales

Family: Fabacaeae

Genus: *Vigna*

Species: *Vigna unguiculata*

Snake bean also known as string bean, snap pea, yard-long bean, chinese long bean, snake pea, bodi, pea bean, and asparagus bean. Its chromosome number is 2n = 2x = 22 (Rambabu et. al, 2016).

Snake bean is a dicotyledonous species as a significant part of the seed, has two cotyledons (seed leaves). It has the following morphological (structural) features such as purple or black colored kidney-shaped seeds at mature stage, two cotyledons, 8 to 10 cm long trifoliate (divided into three leaflets) leaves with ovate (egg-shaped) leaflets; and violet or yellow flowers (Khatri et al., 2015).

The snake bean grows on twining, delicate stems with a tenacious root system. Then, a pair of large white or purple flowers are produced. Once pollinated, the flowers are followed by tiny dark green beans that reach 30 cm long in only a few days (Lawrence, 2007). The stem is square, usually smooth and often round with a node usually purple. The stems are generally glabrous, green, and up to 5 mm across. There are many varieties that can be distinguished by seed color and pod (fruit) character. Some types have been chosen for their compatibility in hot climates and warmer weather or slightly cool and dry climates (Owens, 2003).

Robyn (2013) described snake bean is an annual herbaceous vine. The petioles are up to 10 cm long without pubescence, thickened at the base. The stipules (0.6-1.5cm) are lanceolate, peltate, and narrow at the attachment point. Propagation of long bean is by seed. Its long, trailing growth requires a trellis or pole for better growth and good production. The plant will climb by itself, but still needs some help from people and a very strong trellis system. Many pollinators attracted to the plant, specifically various types of yellow jackets and ant (Toppo and Singh, 2018).

The plant begins to produce marketable pods in 60 days after sowing. At that stage the pods, hang in pairs, ranging from 35 to 60 cm in length. Quality of pod is based on the pod colour and length; different markets have differed desirable qualities. People in Thailand and Hong Kong prefer light green and extra-long pods; Brunei prefers dark green, short pods, while European and Canadian markets prefer dark green, and medium pod length (Toppo and Singh, 2018).

2.2 Agronomy of *Vigna unguiculata*

Snake bean (*V. unguiculata* ssp. sesquipedialis) is a distinctive subspecies of cowpea. It can be adapted to a wide range of environmental stimuli such as drought and heat. Nevertheless, it is an extremely cold-sensitive tropical species. Snake bean grow well in warmer climate and frost intolerance. Moisture humidity is especially preferred with consistent rainfall (Owens, 2003). During the growing period, optimum average temperature is 20ºC to 30ºC. Full sunshine encourages the growth and development, whereas cloudy and rainy weather cause flowers and young pods to drop and cause low yield (Toppo and Singh, 2018). To increase snake bean production and prolong its supply, improvement of chilling tolerance in may significantly (Tan et. al, 2016).

Snake bean can be cultivated in different type of soil such as peat, sandy loam, clay and bris but the soil must provide with good drainage, soil pH between 5.5 to 6.8 and an optimum crop management. The best site preparation in low lands is by plot and fitted with plastic silver shine for weed and disease control. The sprinkler irrigation is the suitable method for watering the snake bean. The sprinkler head is above the level of trellis (Anem, 2012).

During harvesting, it is important to ensure not to harvest the buds which are above the beans because on the same stem, the plant will set many more beans. The plants take longer period to mature than bush beans, but once developing, the beans are quick-growing and necessary to daily checking for harvesting. The plants produce beans until they reach the limit. Snake bean is a self-pollinating annual crop with a climbing vine. Natural cross-pollination between snake bean plants in a row is less than 1% (Toppo and Singh, 2018).

Snake bean is very attractive to aphids (*Aphis craccivora*, *Myzus persicae* and *Aphis gossypii*), green stink bug (*Nezara viridula*) and red spider mite (*Tetranychus* spp.). Greasy cutworms (*Agrotis ipsilon*) often causes damage only after the appearance of the branches yard-long bean (Grubben, 1993). Aphids, particularly the black bean aphid (*Aphis fabae*), are attract to the pods of this plant. Thrips tend to be a pest early in the season, but the plants will often get rid of them, especially as the weather gets warmer and the plants grow faster. Mites also can be the problem, primarily after insecticide applications, which often lead to mite outbreak. Furthermore, caterpillar crawler lengai (*Marucca testutalis*), fly beans (*Melanaagromyza phaseoli*) and caterpillar eater (*Eurysops canejus*) are also attacking the snake bean plant. Pest control is carried out by spraying with insecticides, agronomy methods and using cultivars that are resistant to the pest (Anem, 2012).

Snake bean is attacked by many diseases such as anthracnose leaf diseases or anthracnose (due to *Collectricum lidemunthiamun*), leaf spot disease (*Cercospora canescens*), rot palu (*Rhizoctonia solani*), rust disease (*Uromyces appendiculatus*) and disease mosaic virus (Anem, 2012). Since mid-2008, epidemic diseases are severely affected the yellow mosaic symptoms are observed in the snake bean cultivation in agricultural fields in West Java. Indonesian Agriculture Department also announced that the same symptoms were observed (Central Java). In the fields, leaves symptomatic plants showed very bad mosaics yellow symptoms and the description of the resulting vein and pods by this plant is damaged by the symptoms of mosaics on surface (Damayanti et al., 2009). Disease control methods are using chemicals, seeds resistant attack, and agronomic practices which are suitable with condition of area (Anem, 2012).

2.3 Uses of *Vigna unguiculata*

Food legumes provide low-fat protein in the human consumption and hence are considered as "meat for the poor" (Heiser, 1990). They are also important as high quality livestock fodder and residual nitrogen suppliers in soil, fixing atmospheric nitrogen (Leikam et al., 2007). Snake bean gives the profit to the country because of its highest economic value. Tey *et al.* (2007), showed that Malaysian food consumption pattern is moving towards functional foods in response to income growth. This is because of the population of people increase and lead to higher demands of the snake bean. Thus, the country needs to upgrade the production and yield of the snake bean to fulfil the demand.

The snake bean is full of nutritional value so many people love to consume it. Young and immature pods have very high calorie as for 100 g snake bean contains 47 calories. Snake bean pods contain high quantities of soluble and insoluble fibres. Dietary fiber can protect the mucous membrane of the colon by get less the exposure period to toxic substances such as binding to cancer causing chemicals in the colon. Vegetables that rich of fiber also helps to reduce LDL-cholestrol levels by decreasing re-absorption of cholesterol binding bile acids in the colon (Hossain et al., 2013).

Snake bean also contains many nutrients. Snake bean is filled with protein, phosphorus, riboflavin, calcium, iron, potassium, and vitamin A. It has more vitamin A than the other of legume family such as fava beans, green beans and lima beans. Vitamin A is the essential vitamins to our body for maintain mucus membrane integrity, improves night vision and enhances skin complexion (Hossain et al., 2013). The pods are picked when they are still smooth and immature, before the pod swell. They are eaten fresh, frozen, or canned. At this young and tender stage, they can be prepared in various ways (National Research Council, 2006). They are best for consumption if harvest before they matured; however, overlooked pods can be consumed as dry beans in soups (Toppo & Singh, 2018).

2.4 Mass Selection

Mass selection is the oldest plant breeding method (Allard, 1960) and probably the most used over time (Abreu et al., 2010). It is simple, rapid and low costing permitted to obtain substantial grain yield gains in maize (Rahman et al., 2007) although it is usually lowly efficient for lowly heritable traits like grain yield. The experiment using the selection has shown sufficient potential for improvement in oil and protein of maize for generations to next generation (Dudley and Lambert, 1992). Mass selection is the most basic technique used for crop improvement, to pick the desirable plants in the breeding process. (Acquaah, 2017). The advantages of the mass selection are rapid, simple, low cost, straightforward and large population can be handled by use one generation per cycle (Acquaah, 2007). It is an easy selection method that needs natural environmental conditions to alter the genotypic frequency of an open-pollinating population (Caligari and Brown, 2017). Its efficiency depends primarily on gene frequencies in the original population and the heritability of the character selected. Highly heritable characters respond well to mass selection. In corn, high possibility to develop varieties differing in grain colour, plant height and size of ear because they are highly heritable character. Mass selection with high heritability, successful in segregating population of self-pollinated species such as soybean, barley and oat. However, when mass selection for less heritable characters such as yield give variable results (Achmad, 1984).

Mass selection is method that individual plants with desired traits were selected and used as a source of seed for the following generation. The seeds of selected plants are bulked without control of population. The result in a population quickly moving toward equilibrium that can be maintained, as a population, for exploitation. To avoid any unwanted cross-pollination, mass selection plots need to be isolated from other crops of this species (Caligari and Brown, 2017). Mass selection for characters controlled by a single gene or for those with a high heritability can simply be undertaken. However, more difficult in the selection genotype with high yield. As yield is the end point of the physiological development of a plant, all genes involved in development must be considered yield genes. The efficiency of mass selection is influenced by the type of gene action determining the characters under selection. If yield is determined by genes which are addictive, completely dominant, complementary or conglomerate, mass selection should increase the desirable gene frequency (Achmad, 1984).

CHAPTER 3

MATERIALS AND METHODS

3.1 Plant and other Materials

This research used 240 snake been seeds selected from the longest pods in third generation as the plant materials. For this experiment, one roll of silver shine plastic was used to cover the plot. The fertilizers NPK in ratio 15:15:15 and urea was applied to the planting area for helps the plant grow well. The compost also applied in each of the plot. The basic equipment's of planting such as hoe, rake, watering can, bamboo marker, trowel and rolls of raffia rope for the land preparation.

3.2 Methods

3.2.1 Description of the study area

The experiment on snake bean was done at the AgroTechno Park Universiti Malaysia Kelantan, Jeli from early April 2018 until the middle of June 2018. It is located 8.2 km from Jeli town; at latitude 5.7° N and longitude 11.8° N. The climate in Malaysia is tropical rainforest climate; so the weather is hot and moist. The map of research location is in Figure 3.1 below.

Figure 3.1: The research location is in “Agropark UMK Jeli Campus” (Google Map, 23 November 2018)

3.2.2 Land Preparation

The process of planting snake bean started with clearing the land site. The selected land site was cleared from the weed and rock. The plots of snake bean were prepared with eight plots of the soil with two rows each. Eight plots were prepared with the size of 9 m x 0.8 m long by hoe and trowel. One plot required 30 seeds of the snake bean that is show in Figure 3.2.

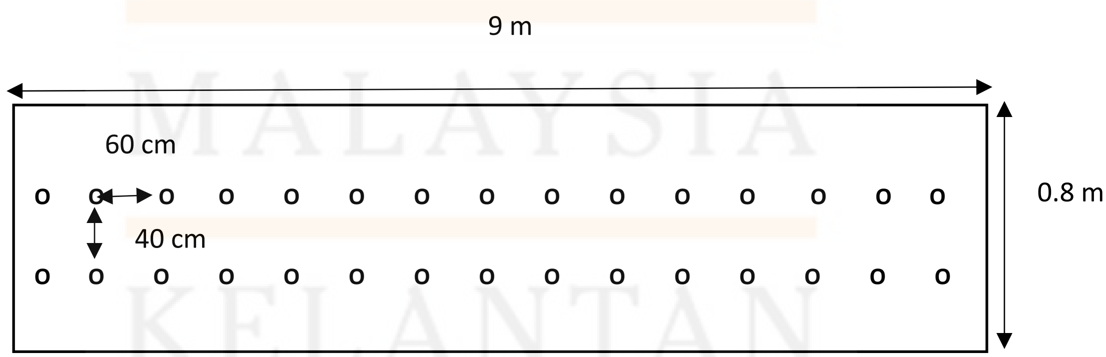

Figure 3.2: The plot of each snake bean.

Next, each plot was mixed properly with 9 kg of compost. The plots also mixed with chemicals fertilizers before covered by silver shine plastic. The fertilizers used were NPK in ratio of 15:15:15 and urea. Both fertilizers applied at 270 g for each bed. The plastic silver shine used to prevent the growth of weed and maintain the moisture of plot. After that, the holes made on the beds using a sharp can. Then, the seeds of snake bean were planted by sowing in the tray.

After one week, the seedlings from the tray were transferred into each holes in the plot. The planting distance was 60 m x 40 cm each. The plants were watered frequently to help the plant grow healthy. The watering process was done in early morning and late evening. Then, in two weeks after transplanting, the trellises were set up. The snake beans have grown by climbing the trellis.

The growth of the snake bean plant was observed. The snake beans were harvested after matured. The length and weight of pod were measured and recorded. While, the longest' pods were left on the plant to be dried, get matured and old enough to be cultivated in next generation. The seeds were counted and keep for next generation.

3.2.3 Data Collection

Data collection was carried out after the germination process until the end of harvesting of snake bean. The snake bean with the highest yield and length pod were selected and labelled. Snake bean pods would be collected for the next generation method. The variables observed is both vegetative and generative growth in this experiment.

a) Plant height (cm): the measurement of the plant stem from the above soil level until shoot tip.

b) Number of leaves per plant: total leaves produced per plant.

c) Number of flowers per plant: total flower produced by plant

d) Pod length (cm)

e) Pod weight/yield (g)

3.2.4 Data Analysis

The collected data on different parameters were analyzed using the descriptive statistic and heritability such as pod length and yield of snake bean. The descriptive data presented by using Microsoft Excel were the mean and standard deviation. The narrow sense heritability was used for this snake bean experiment as follow (Mackay et al., 2009).

$$h^2 = \frac{R}{S} \qquad \text{Equation 1}$$

Where R: T_o - μ

S: T_s - μ

μ: Mean of population

T_o: Mean of selected offspring

T_s: Mean of selected parents

R: A measurement how much the mean has changed in one generation

S: Differences between the mean of selected parents and the mean of population

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Vegetative Parameter

The vegetative parameters that were observed in this experiment included plant height and number of leaves. All of the parameter were measured and recorded from the first week until eighth week.

4.1.1 Plant Height

One of the important parameters is the plant height which it can show the development growth of particular plants. In this research, the height of plant was measured precisely by using the measuring tape in eight weeks. From the first week until eighth week the data was recorded. Based on the Figure 4.1 below, it shows the average number of plant height per week.

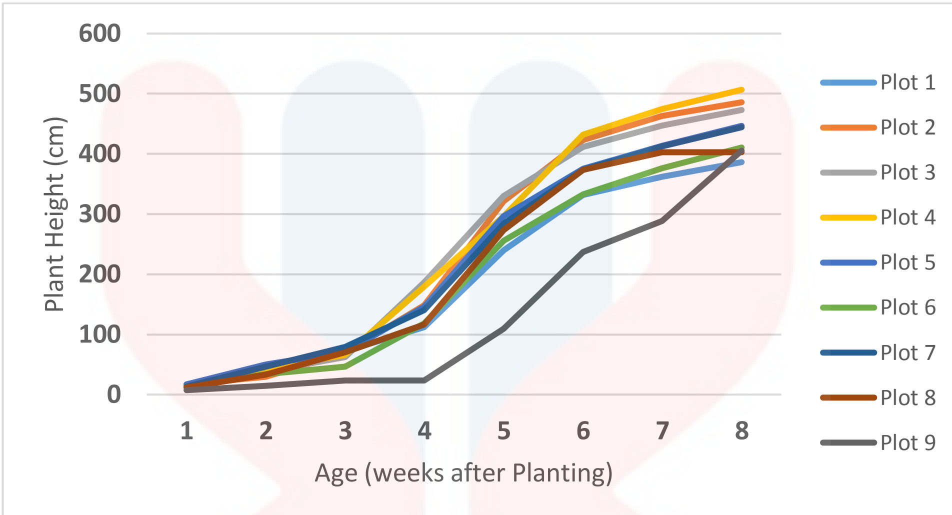

Figure 4.1: The average of plant height per week

Figure 4.1 above shows the average value of plant height of sample plants for each week. From the figure, the highest value shown in first week is from plot five which is 17.0 cm while the lowest is from plot eight; (11.8 cm). For third week, plot seven shows the highest value 79.0 cm followed by plot one, five, eight, two, four, three and six with 72.5 cm, 71.7 cm, 70.7 cm, 69.3 cm, 66.2 cm, 62.2 cm and 46.2 cm respectively. The mean of the plant height shows increasing value from the first week until the last week. Basically, the higher number of mean shows the plants produce large number of plants height.

Based on data recorded, Figure 4.1 shows that the plant was growing up by week. Plot four dominate the height of sample plants followed by plot two, three, seven, six, eight and the last is plot one. The plant height was slow in first week until fourth week. However, it got increase faster in week fifth until week eight. The increasing of plant height indicate that the plant gains full requirement needed such as fertilizer and water.

4.1.2 Number of leaves

Number of leaves also recorded from first week until eighth week. The leaves were counted from the top of soil level until the shoot. The leaves are count wisely for each sample plant. Based on the Figure 4.2 below, it shows the average number of plant height for each plot.

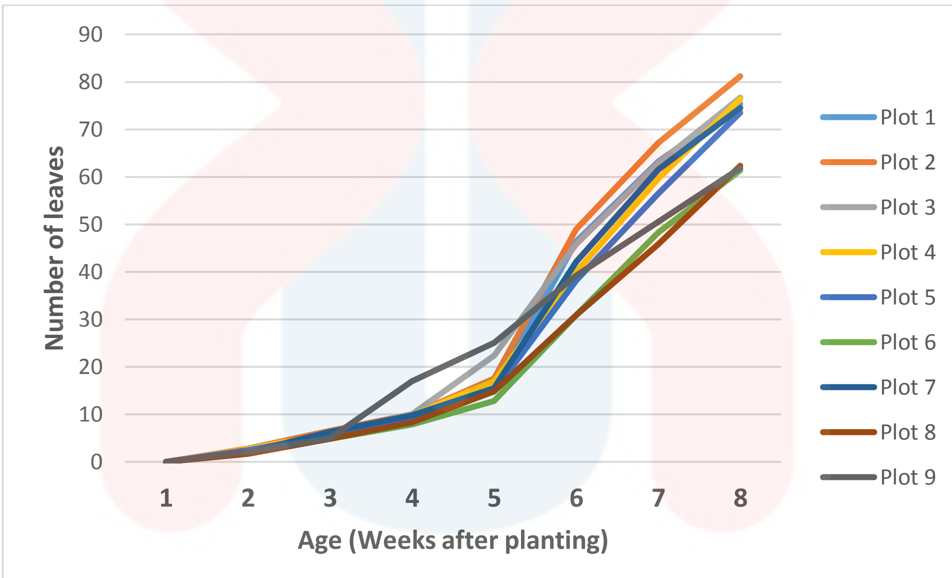

Figure 4.2: The average of number of leaves per week

Data gathered in Figure 4.2 above shows the average number of leaves of sample plants for each plot. From the table, the highest value shown in third week is from plot four which is 9.8 while the lowest is from plot eight; 4.8. For eighth week, plot two shows the highest value 81.2 followed by plot three, four, one, seven, five, eight and six with 76.7, 76.3, 75.3, 74.5, 73.5, 62.3 and 61.3 respectively. The mean of the plant height shows increasing value from the first week until the last week. Basically, the higher number of mean shows the plants produce large number of plants height. Furthermore, The Figure 4.2 shows the graph of average number of leaves for every plot by the week.

Figure 4.2 shows the production of leaves are highest in Plot 2 followed by Plot 3, Plot 4, Plot 1, Plot 7, Plot 8 and lastly Plot 6. The number of leaves are slightly increase in first week until fifth week. After fifth week until eighth week, the development of leaves increase rapidly in all eight plot. This shows that in fifth week, the plant get all needed for the production of leaves such as water, sunlight and carbon dioxide. In early five weeks, the basic need of the plants; especially water is very low in quantity. It also because the hot weather that allows the leaves wilt. The number of leaves higher, the growth of plant also higher. This is because the leaves make the process of photosynthesis.

4.2 Generative Parameter

Generative growth is the process where the plants produce flowers and fruit. In this research, the parameter that observed are the number of flowers, the number of pods per plot and pod length.

4.2.1 Number of flowers

Number of flowers are counted when the flowers start bloom. Flowers are important for produced seed and fruit. The number of flowers recorded in sixth week until eighth week. The Figure 4.3 below shown that production of flowers starts from sixth week until eighth week. The number of flowers slightly increase for all plot. The highest plot is Plot 1 and Plot 7 followed by Plot 2, Plot 3, Plot 6, Plot 4, Plot 8 and Plot 5.

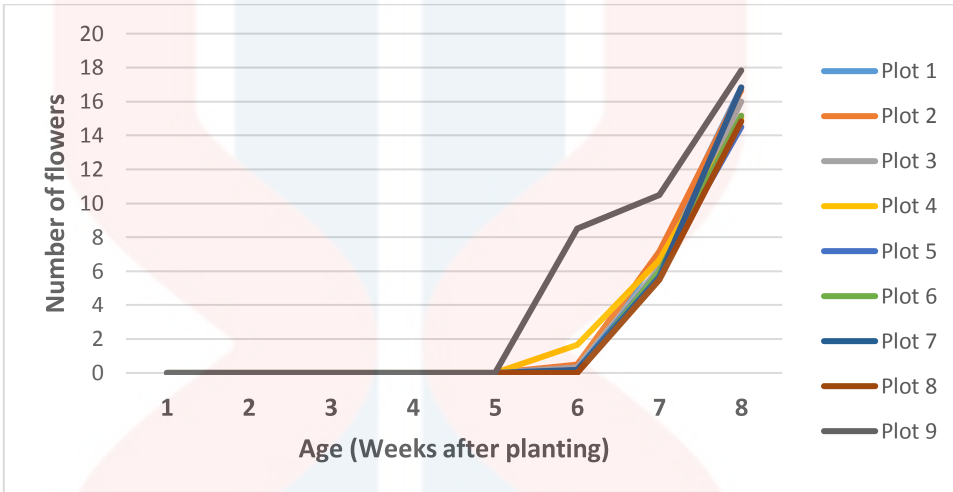

Figure 4.3: The number of flowers of sample plant per week

The number of flowers can lead to the number of fruit (pod length). Flowers develop into fruits; when blooms and do fertilization process. The more number of flowers, the more number of fruit (pod length). However, the production of flowers can restrict by the surrounding effect such as pest like ant and the weather condition (heavy rain). This situation can cause the flower failed to produce.

4.2.2 Number of pods per plot

Table below shown the number of pods per plot that are measured and recorded. The harvesting of snake bean are starts from week seven for pod length below than 75 cm and the pod length more than 75 cm were left and picked in week nine. The pod length more than 75 cm are selected and bulk the seed for next generation.

Table 4.1: The number of pods per plot

Plot	Number of pods per plot	Yield per plot (g)
Plot 1	1096	27270.5
Plot 2	1018	20095.7
Plot 3	904	22844.2
Plot 4	867	18943.8
Plot 5	849	23764.6
Plot 6	676	16556.1
Plot 7	747	20684.9
Plot 8	840	19780.2
Total	6997	169939.9

From the table 4.3 below, Plot 1 has the highest number of pods which is 1096 followed by Plot 2 (1018), Plot 3 (904), Plot 4 (867), Plot 5 (849), Plot 8 (840) and Plot 7 (747). The lowest number of pods is Plot 6 (676). The highest yield per plot is Plot 1 (27270.5 g), Plot 5 (23764.6 g) and Plot 3 (22844.2 g) and followed by Plot 7 (20684.9 g), Plot 2 (20095.7 g), Plot 8 (19780.2 g), Plot 4 (18943.8 g) and lastly Plot 6 (16556.1 g).

This experiment showed that Plot 1, Plot 5 and Plot 3 has the higher yield of pods that resemble the dominant traits of this snake bean plant. While, Plot 7, Plot 4, Plot 8, Plot 3 and Plot 2 has present the recessive traits of snake bean plant which is less yield of plant. The criteria of yield per plot were depends on the optimum size and longest of snake bean harvested. The longer the pod length, the more yield per plot.

4.2.3 Pod length

The length of pod and frequency of different range of pod length in zero generation, first generation, second generation, third generation and fourth generation were represented as Table 4.2. The table also include the mean and standard deviation of each generation. The range of pod length were shown in Figure 4.4.

Table 4.2: The frequency of different range of pod length in zero generation, first generation, second generation, third generation and fourth generation. [(a)]

	Frequency of Pod in				
Pod Length (cm)	Zero Generation (%)	First Generation (%)	Second Generation (%)	Third Generation (%)	Fourth Generation (%)
15-19.9	0 (0)	0 (0)	0 (0)	1 (0.02)	1 (0.01)
20-24.9	0 (0)	19 (0.43)	3 (0.05)	14 (0.29)	21 (0.3)
25-29.9	3 (0.38)	30 (0.68)	11 (0.19)	37 (0.76)	76 (1.09)
30-34.9	4 (0.51)	49 (1.11)	43 (0.76)	63 (1.31)	265 (3.79)
35-39.9	6 (0.76)	122 (2.77)	88 (1.55)	187 (3.88)	397 (5.67)
40-44.9	26 (3.30)	661 (14.99)	234 (4.13)	421 (8.73)	598 (8.55)
45-49.9	172 (21.86)	727 (16.49)	456 (8.05)	654 (13.56)	911 (13.02)
50-54.9	185 (23.51)	1173 (26.60)	762 (13.45)	777 (16.11)	1144 (16.35)
55-59.9	178 (22.62)	1369 (31.04)	1197 (21.13)	817 (16.94)	1293 (18.48)
60-64.9	110 (13.98)	116 (2.63)	1157 (20.42)	730 (15.13)	1077 (15.39)
65-69.9	73 (9.28)	56 (1.27)	858 (15.14)	569 (11.79)	794 (11.350
70-74.9	28 (356)	55 (1.25)	533 (9.41)	333 (6.90)	349 (4.99)
75-79.9	2 (0.25)	20 (0.45)	232 (4.09)	142 (2.94)	58 (0.83)
80-84.9	0 (0)	12 (0.27)	64 (1.13)	52 (1.08)	8 (0.11)
85-89.9	0 (0)	1 (0.02)	25 (0.44)	20 (0.41)	4 (0.06)
90-94.9	0 (0)	0 (0)	3 (0.05)	7 (0.15)	1 (0.01)
Total	787	4410	5666	4824	6997
Mean	49.63	51.32	54.72	56.17	54.31
Standard Deviation	8.5	8.43	9.72	11.13	10.80

[(a)] Data of zero generation, first generation, second generation, third generation were obtained from previous student thesis.

Based on Table 4.2, the mean in zero generation to third generation is increasing which are zero generation (49.63cm), first generation (51.32cm), second generation (54.72cm) and lastly third generation (56.17cm). However, the mean for fourth generation is slightly decrease (56.17cm to 54.31cm). This happen because of the environmental factors such as the location take place, the uncertainty weather and the presented of pest. The location take place is near the jungle, so many pest and disease can spread easily to the snake bean plant. Furthermore, the early phases of planted snake bean, the weather is hot and sunny. The snake bean plant get not enough water for the healthy growth. Moreover, the rainy weather is occurred during the last phases of planting as harvesting period. It is lead to many pest and disease attract to the snake bean plant. The pest and disease must be preventing from the early stages of the vegetative growth. For the lack management, the process is late and make the snake bean plant are attacked with insects and disease.

The standard deviation for zero generation to first generation (8.5 to 8.43) and third generation to fourth generation (11.13 to 10.80) are slightly decrease. The standard deviation from first generation to third generation is increasing from 8.43, 9.72 and 11.13. The standard deviation is used to show the variability of pod length. From the research, the standard deviation in fourth generation (10.80) is slightly decrease from third generation (11.13) but still higher than second generation (9.72). It shows that the pod length still in segregation and can produce the higher value of pod length.

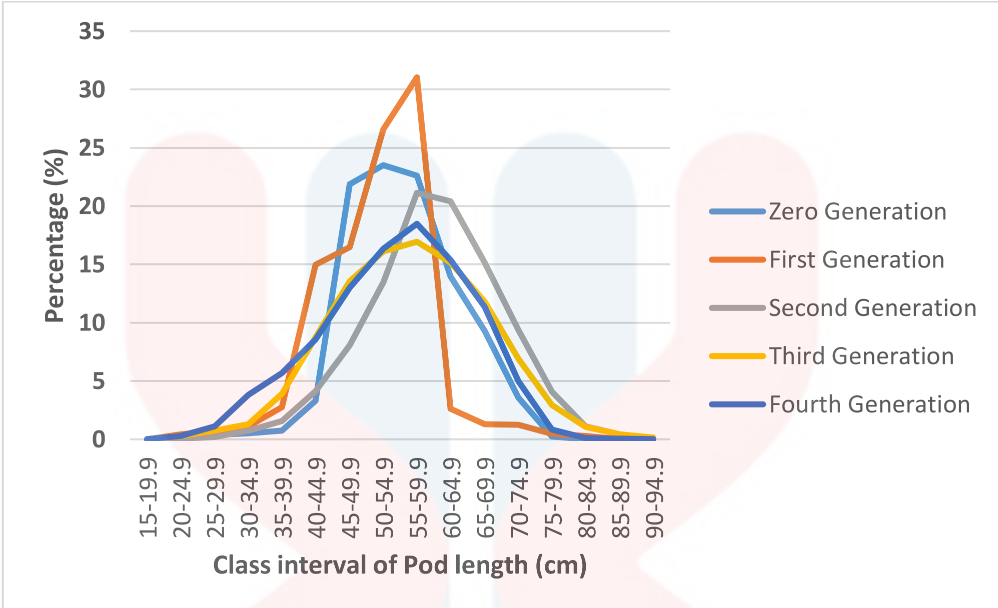

Figure 4.4: The Range of pod length

Figure 4.4 above shown that the different range of pod length in zero generation, first generation, second generation, third generation and fourth generation. It shows the mean of the pod length slightly increase through the generation. But, slightly decrease from third generation to fourth generation. This is because many of the snake bean plant were died in early phase of planting because of the hot weather.

4.2.4 Heritability

Based on table 4.3 below, mean of population is 56.17, mean of offspring is 54.31 and mean of selected parents 84.99. The different between mean of offspring and mean of population is -1.86 and the difference between mean of selected parents and mean of population is 28.82. The heritability of this research is -0.06. This is because the mean of population was higher than the mean of offspring. The negative heritability means that individuals that have same genotype may have a slightly different traits compared to high different genotypes (Steinsaltz et al., 2017).

Table 4.3: The narrow sense of heritability of fourth generation

Generation	fourth Generation
μ, mean population	56.17
T_o , mean offspring	54.31
T_s , mean of selected parents	84.99
R (T_o - μ)	-1.86
S (T_s - μ)	28.82
h^2 = R/S	-0.06

CHAPTER 5

CONCLUSION AND RECOMMENDANTION

5.1 Conclusion

Mass selection technique is suitable method for increasing the yield of snake bean by improving the pod length as proven from this study that the mean of pod length and the yield from zero generation to third generation always increased. The yield of snake bean in previous generation (third generation) was 161.0 kg and for yield of this generation (fourth generation) of snake bean was 169.9 kg. However, the mean value for fourth generation of snake bean was 54.31cm slightly lower than that of third generation (56.17cm) due to some environmental factors. Consequently, the heritability of snake bean in this generation was negative (-0.06).

5.2 Recommendation

By proper management in conducting experiment, mass selection technique can be continually used to increase the pod length and yield of snake bean for the further generation.

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APPENDICES A

Table A.1: The average value of plant height of sample plant per week (cm)

Plot	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	16.3	33.5	72.5	112.5	239.7	331.8	362.0	386.3
2	16.8	30.0	69.3	148.5	321.7	423.0	462.8	485.8
3	13.3	38.8	62.2	186.5	330.3	412.0	447.2	473.0
4	14.0	43.8	66.2	179.7	296.5	431.8	474.8	506.7
5	17.0	50.0	71.7	145.8	296.5	375.7	413.8	446.7
6	13.7	34.2	46.2	118.0	255.7	333.0	376.5	410.7
7	13.3	46.2	79.0	140.3	284.2	374.0	413.0	444.3
8	11.8	32.8	70.7	116.2	273.2	373.8	402.8	402.8
Mean	14.6	38.7	67.2	143.4	287.2	381.9	419.1	444.6

Table A.2: The average value of number of leaves of sample plant per week

Plot	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	0	2.2	5.2	8.2	15.2	46.3	63.2	75.3
2	0	2.8	6.5	10.0	17.5	49.0	67.2	81.2
3	0	2.2	6.0	10.0	22.3	45.8	62.8	76.7
4	0	2.7	5.8	9.8	17.0	40.0	59.7	76.3
5	0	2.5	5.5	8.8	14.8	38.2	56.5	73.5
6	0	2.0	4.8	7.8	12.8	30.8	48.3	61.3
7	0	2.0	6.3	9.8	15.5	42.2	61.5	74.5
8	0	1.7	4.8	8.3	14.8	30.8	45.8	62.3
Mean	0	2.3	6.1	9.1	16.3	40.4	58.1	72.7

Table A.2: The average value of number of leaves of sample plant per week

Plot	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	0	0	0	0	0	0.2	7.0	16.8
2	0	0	0	0	0	0.5	7.2	16.7
3	0	0	0	0	0	0.3	6.2	16
4	0	0	0	0	0	1.7	6.7	15
5	0	0	0	0	0	0.2	6	14.5
6	0	0	0	0	0	0	6	15.2
7	0	0	0	0	0	0.2	5.7	16.8
8	0	0	0	0	0	0	5.5	14.8
9	0	0	0	0	0	8.5	10.5	17.8
Mean						0.4	6.3	15.7

Appendices B

Figure B.1: The preparation of snake bean plot

Figure B.2: The snake bean plant in early stage.

Figure B.3: The yield of snake bean