

Intercropping System Affect PH, Moisture Content and the Presence of Nitrogen, Phosphorus and Potassium (NPK) in Soil at Karas Plantation Area

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Abstract---Intercropping is very popular in agricultural sector nowadays because this practice can give high returns to the farmers and planters. However, the intercropping system practised by farmers and planters has affected the soil physical properties. The aim of this research is to study the effects of short-term crops in karas plantation to the soil physical properties (soil pH, soil moisture content and the presence of nitrogen, phosphorus and potassium in soil). Soil pH was measured using pH metre whereas soil moisture content (%) was measured by weighing method. Kjeldahl method was used to determine the presence of nitrogen in which three process were involved – digestion, distillation and nitrification. Meanwhile, phosphorus was analysed using UV-VIS spectrophotometer whilst potassium was determined using ICP-MS. The results were analysed using descriptive statistics (mean and frequency) and inferential statistical (One-way Analysis of Variance, ANOVA).

The results were expressed in mean value \pm SEM ('standard error mean'). The present findings showed no significant difference ($p < 0.05$) in soil pH, soil moisture content (%) and NPK in all short term crops which are chilli, corn and okra before and during the plantation of the crops as well as after the removal of the crops from the study site when compared to the control. The intercropping system of chilli, corn and okra in karas plantation did not give any negative impact to the soil pH, soil moisture content and NPK. In conclusion, intercropping system did not affect the whole karas trees growth and may help in generating higher profits for the karas planters in the future.

Keywords: Karas plantation, Intercropping system, pH, moisture content, NPK

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I. INTRODUCTION

Intercropping system is a practice of planting two or more crops in the same field or at least at the same time Mousavi & Eskandari, 2011). It is generally important to developing countries where agricultural land is limited (Ahmad et al., 2013). According to Bakry, Salman & Moussa (2017), intercropping system or known as polyculture is the cultivation of two or more plants species in the same field. Today, intercropping system is very popular in agricultural sector and this system has been practiced in China more than 2000 years ago (Li, Li, Sun, Zhang & Christie, 2003). According to Raja Zulkifli Raja Omar, Wahid Omar and Norkaspi Khasim (2010), intercropping system can maximise the use of land and can generate extra income for the farmers. The common intercropping plants planted with the primary plants are short-term crops or cash crops.

Short-term crops are crops that only require short period of time to produce and it takes less than a year to harvest and it can be the cash crops (Fikri Mastor, 2016). According to Fikri Mastor (2016), mustard green, spinach, water spinach and okra are vegetable crops that require the shortest harvesting time which is four weeks followed by French bean, long bean, corn, cucumber, cabbage and pumpkin that take three months to harvest. On the other hand, tomato, aubergine, chilli and young ginger take about six months to harvest while ginger and tapioca can only be harvested eight to nine months after being planted (Fikri Mastor, 2016).

The three types of short-term crops which are chilli, okra and corn were chosen to be integrated with karas trees. The high demand for chilli and okra which has been reported by Department of Agriculture of Peninsular Malaysia (2017) and Department of Agriculture of Peninsular Malaysia (2018) was the main reason for the selection of these two short-term crops. Corn is a great food source since it can produce various food products such as corn oil, corn cordial, corn flour and animal feeds (Mohamad Hussin, 2016). In addition, corn is also in high demand by animal feeds manufacturer due to its better quality and freshness compared to the imported corn (Mohamad Hussin,



2016). According to the Director of Malaysia Department of

Agriculture Datuk Ahmad Zakaria Mohamad Sidek, local farmers are encouraged to plant corn to guarantee the quality of corn as well as to reduce the total national trade import of food (Junita Mat Rasid, 2017).

However, intercropping system practised by farmers and planters affected many aspects of the physical properties. The affected physical properties were soil fertility, soil pH and soil moisture content (Jones & Olson-Rutz, 2016; Mastuti, 2016). The purpose of this research is to study the effects of physical properties such as soil pH, soil moisture content as well as the presence of nitrogen, phosphorus and potassium in the soil after planting short-term crops in karas plantation.

II. METHODOLOGY

a) Intercropping System

About ten plots of karas plantation were planted in an area of 0.25 acres. The area of each plot of karas was 3048cm x 1829cm which can accommodate 77 karas trees. The three types of short-term crops which were chilli, okra and corn were chosen to be integrated with karas trees. Each crop was planted in three predetermined separate plots and plot 2, plot 7 and plot 9 were for chilli. Okra was planted in plot 4, plot 8 and plot 10 whereas corn was planted in plot 3, plot 5 and plot 6. Plot 1 was the control plot on which no short-term crop was planted.

b) Soil Quality Determination

Soil quality is the measure of the effectiveness of soil in providing nutrients and water to the plants and organisms in it as well as recycling important nutrients to the plants. In this study, the measure of soil quality was carried out to determine the soil pH, soil moisture content and nutrient content in the soil.

c) Soil Sampling

The soil sampling was carried out in two cycles and each cycle was measured three times which were before the crops were planted, during the crops were planted and after the crops were removed from the study site. The sample of soil was taken using random sampling technique. About 500 g of soil was taken randomly in three locations in every plot at a depth of 0-15 cm using a hoe. The depth is suitable for the conventional test of determining pH value, phosphorus (P) and potassium (K) in the soil. The three random collected soil samples in every plot were mixed together in a container and any traces of non-soil element like roots, small stones and grass were removed from the soil sample. The mixed soil samples were divided into four parts where two opposite parts were thrown away whilst another two opposite parts were mixed again and taken to be analysed. The soil samples taken were wrapped in a clean plastic, labelled and sent quickly to the laboratory to be analysed. Next, the soil samples were divided into three parts in order to test its pH value, soil moisture content and soil nutrient content.

Soil pH

The soil sample taken was tested for its pH value to determine the acidity of soil in the study site. The main objective of pH test is to study the effect on soil acidity after the short-term crops are planted on the karas trees plantation areas. About 50 g of soil was taken in every plot of karas plantation in which pH meter device was used to determine the pH value of the soil sample. The soil sample was transferred into a flask and dissolved in distilled water. pH meter was calibrated before testing the soil sample to prevent any error on the pH value reading. The reading of pH value was taken three times to ensure accuracy and consistency. The reading was then recorded on data sheet.

Soil Moisture Content

The measurement of soil moisture content in karas plantation area was carried out using gravimetric technique by weighing dried soil unit (g water/g dried soil). This technique is easy, cheap and time efficient. The purpose of measuring soil moisture content is to determine whether the short-term crops can help in increasing the ability of the soil to hold water and optimize the growth of karas trees. The weight of moist soil was weighed by taking 50g from each plot and dried overnight (24 hours) in an oven at the temperature of 105° C. The soil was weighed again after 24 hours until the constant weight was achieved. Three replications were done on the soil sample for each plot to obtain the average value.

The average value of soil moisture content is calculated based on the following formula:

$$\% \text{ Soil Moisture Content} = \frac{Bb \text{ (g)} - Bk \text{ (g)}}{Bk \text{ (g)}} \times 100$$

Bb is 'moist weight' without container whereas Bk is 'dried weight' without container. The difference between 'moist weight' and 'dried weight' is the weight of water content loss in the soil during the drying process.

Soil Nutrient

The nutrient content determination in soil is important to ensure proper and healthy growth of karas trees. To determine the nutrient elements contained in the soil, dried soil sample was grounded into powder and filtered using anti-corrosion steel with hole size of 2mm to remove any larger stone and to get homogenous and finer size of soil. In this study, the soil sample collected to determine the nutrient content was sent to Universiti Kebangsaan Malaysia (UKM) to be analysed.

a) Nitrogen (N)

The organic nitrogen content contained in the soil was measured using Kjeldahl method. This method involved three processes which are digestion, distillation and nitration.

i) Digestion

The aim of digestion process is to break the organic nitrogen bonds in the soil sample so that it can form ammonium ion (NH₄⁺) while organic carbon and hydrogen will be converted to carbon dioxide and water. About 0.3 g air-dried soil was weighed and transferred into digester tube with 7 ml of sulphuric acid (H₂SO₄). This procedure was carried out in fume hood.



About 7 g of potassium sulphate (K_2SO_4) and 5 mg selenium that act as catalysts were added into the sample. The presence of potassium sulphate helps in increasing the boiling point while the catalyst reduces the time taken for the process to take place. About 5 ml of hydrogen peroxide (H_2O_2) 35% was added into the sample and shaken. Then, the sample was transferred into the digestion machine (Foss Digester 2508) at the temperature of $360^\circ C$ for 30 minutes. After the process, the sample was cooled down in the fume hood.

ii) Distillation

The aim of distillation process is to separate ammonia (nitrogen) from the digestion mixture obtained from the previous process. Before carrying out distillation process, preparation for indicator was done by dissolving 40 g boric acid (H_3BO_3) into 1 litre of warm water ($60-70^\circ C$) to get 4% boric acid solution. Then, 0.1g bromocresol green and 0.1g methyl red that had been dried in oven and cooled down inside desiccator were mixed into 100 ml ethanol respectively. After that, 10 ml of green bromocresol and 7 ml of methyl red were mixed into 1 litre of 4% boric acid solution prepared earlier.

Before the sample was put into the distillation machine (VELP Scientifica UDK 127), the machine needs to undergo wash down process for the first use or if it has not been used for a long period of using digestion tube and an empty Erlenmeyer flask for 3 minutes. After it was done, digestion process was carried out on the sample. About 50 ml of distilled water and 25 ml of 4% boric acid solution were added into the sample inside the digestion tube while 25 ml 4% boric acid solution and 10 ml hydrochloric acid 0.1N were added into Erlenmeyer flask.

Both samples inside the tube and Erlenmeyer flask were put into the digestion machine at the set time of 5 minutes and the amount of sodium hydroxide was set at 35%. After the digestion process, the sample inside Erlenmeyer flask showed a change of colour where the colour turned into pink.

iii) Nitration

About 100 ml of sodium hydroxide 0.1N solution (Normality) was poured into a burette. The sample inside Erlenmeyer flask was titrated until the pink colour changes to light blue. After that, the volume of sodium hydroxide solution with the concentration of 0.1N (Normality) reduced in the burette was measured to determine the total content of nitrogen.

i) Calculation

$$\% N_{\text{sample}} = [(V_{\text{(HCl ml)}} - V_{\text{(NaOH ml)}}) \times 0.1 \times 14]$$

$$\% N_{\text{blank}} = [(V_{\text{(HCl ml)}} - V_{\text{(NaOH ml)}}) \times 0.1 \times 14]$$

$$\% N = (\% N_{\text{sample}} - \% N_{\text{blank}}) / W_{\text{(mg)}} \times 100$$

b) Phosphorus (P)

A study was done to determine the phosphorus content inside the soil sample. Before the phosphorus value was obtained, certain procedures to prepare involved solutions and extracts have to be carried out. To prepare ammonium acetate extract 0.5 M acetic acid 0.5 M, about 1150 ml of acetic acid glacier was diluted to 10 litres (solution A) and

560 ml ammonia solution 35% w/w NH_3 was also diluted to 10 litres (solution B). Then, the same volume for solution A and solution B were mixed together. After that, about 20 g fine air-dried soil sample was poured into a bottle and 100 ml ammonium of acetate-acetic acid extractions were mixed. The bottle containing the soil sample was shaken using shaker for 30 minutes. The sample was filtered into 200 ml flask and closed to avoid any pollution.

i) Solution Preparation Phosphate Determination

To prepare ammonium acetate 1.0 M acetic acid 1.0 M, 115 ml acetic acid glacial was diluted to 0.5 L, whilst about 56 ml of 35% w/w NH_3 ammonia solution was also diluted to 0.5 L. Then, acetic acid with solution concentration of 4 N was mixed with ammonia at a concentration of 2 N. To prepare ammonium molybdate solution, 1.5% weight per volume (w/v), 15g ammonium molybdate was dissolved in 300 ml of warm distilled water. About 310 ml of HCl 36% weight per volume (w/v) was added bit by bit whilst the solution was stirred to cool it down and then, it was diluted to 1L. 1.5% weight per volume (w/v) ammonium molybdate solution prepared earlier was put into big amber glass bottle which lasted for 3 months.

The preparation of phosphorus stock solution which involved 2 milligram phosphorus per millimetre (2 mg P per ml) and about 5 g potassium dihydrogen orthophosphate was dried at the temperature of $105^\circ C$ for one hour and was cooled down using desiccator. Then, 1.7575g of the dried salt was weighed and dissolved into distilled water and was added with 1 ml of hydrochloric acid 36% weight per volume (w/v) HCl. The solution was then diluted to 200 ml and was added with a drop of toluene. The solution was stored and it is stable for 6 months. Then, 200 mg P per ml phosphorus solution was prepared by diluting 10ml phosphorus stock solution, 2 mg P per ml that has been prepared before to 100ml and this solution was stable for one week.

The phosphorus standard solution was prepared by adding 50 ml of ammonium acetate reagent and acetic acid 1.0 M into six beating flasks (100 ml). 200 mg of phosphorus solution per ml prepared earlier was transferred into six beating flasks at a measurement of 0, 1, 2, 3, 4 and 5 ml respectively and was diluted to 100ml. The solution has 0 – 50 μg phosphorus per 5ml in ammonium acetate 0.5 M acetic acid 0.5 M and it was stable for one week. Then, the preparation of stannous chloride standard solution was done by dissolving 10g hydrated chloride stannous with 100ml hydrochloric acid 36% weight per volume (w/v) and then, it was filtered. This solution was stored in amber glass bottle and then stored inside a refrigerator and the solution was stable for 3 months. Then, the preparation of working stannous chloride solution 0.2% weight per volume (w/v) was done by diluting 2 ml stannous chloride standard solution to 100ml and the solution was stable for 8 hours.

i) Standard Graph Preparation

About 5 ml from all six working phosphorus standard solutions that contain 0-50 µg per 5ml were pipetted into 25 ml flat bottom volumetric flask. After that, 5ml of 1.5% ammonium molybdate solution was added into each flask, diluted to 25ml and mixed evenly. 2ml stannous chloride working solution was added and mixed evenly. Density value was read using Spectrophotometer UV-VIS (Hitachi U-1900) at distance of 660 nm after 5 minutes. Graph of optic density against concentration (µg) of phosphorus present was then plotted.

ii) Phosphorus Determination

About 5 ml from each filtered solution was pipetted and 5ml 1.5% ammonium molybdate solution was added and diluted to 25 ml and the solution was mixed evenly. Then, 2ml stannous chloride working solution was prepared freshly and was mixed evenly. The density value was read after 5 minutes using Spectrophotometer UV-VIS (Hitachi U-1900) machine at a wave distance of 60 nm.

c) Potassium (K)

To determine the presence of Potassium, the dried soil was filtered using a filter with hole size of 63 µm to obtain the finer soil or the soil dust. About 1.0 g of dried soil dust was taken and added into 100ml conical flask. Then, 15 ml of concentrated nitric acid (HNO₃) was added and digested for 2 hours on hot plate at temperature 100°C. The sample was heated until the brownish colour vanishes. Sample was then cooled down and 2ml of distilled water and 3ml of 30% hydrogen peroxide were added into the sample. Then, the sample was heated again for 2 hours at temperature of 95-100°C. After the digestion process was completed, the volume of the solution was increased to 100ml and filtered again using Whatman No. 5 filter paper and it was filtered again afterwards using GFC Whatman 45µm filter paper. Potassium element was then determined using ICP-MS (Perkin Elmer ELAN 9000).

Statistical Analysis

Data analysis was carried out using Statistical Package for Social Science software version 20.0. The results of the test were analysed using descriptive statistics (mean and frequency) and inferential statistics (One Way Analysis of Variance, ANOVA). Results analysed were expressed in mean value ±SEM ('standard error mean'). These values were considered significant when the value of p is less than 0.05(p<0.05).

III. RESULTS

a) Soil pH and Soil Moisture Content Analysis (Before, During and After)

Table 1 showed the analysis of soil pH and soil moisture content (before, during and after). According to Table 1, there was no significant difference in soil pH and soil moisture content(%) in all three crops which are chilli, corn and okra before the crops were planted, during the crops were planted and after the crops were removed from the study site when compared to the control group.

Table. 1 PH value and soil moisture content according to the type of short-term crops.

	Type of short-term crops (Min ± SEM)			
	Control	Chilli	Corn	Okra
Before				
Soil pH	6.37±0.79	5.77±0.62	5.63±0.63	6.02±0.73
Moisture content (%)	10.36±2.3	12.13±2.4	13.31±2.7	13.40±2.1
	5	4	8	8
During				
Soil pH	5.51±0.40	4.69±0.51	4.71±0.38	4.98±0.50
Moisture content (%)	9.94±1.26	12.03±1.7	14.36±2.5	13.64±1.5
		6	1	8
After				
Soil pH	4.16±0.20	4.02±0.22	3.97±0.22	4.06±0.22
Moisture content (%)	11.31±0.9	13.22±1.5	13.02±1.4	13.98±0.9
	4	1	1	1

*Note, * The mean difference is significant at p < 0.05*

Figure 1 and Figure 2 showed the soil pH graph and soil moisture content (%) for the three short-term crops and control group which was before the short-term crops were planted, during the short-term crops were planted and after the short-term crops we are removed from the study site.

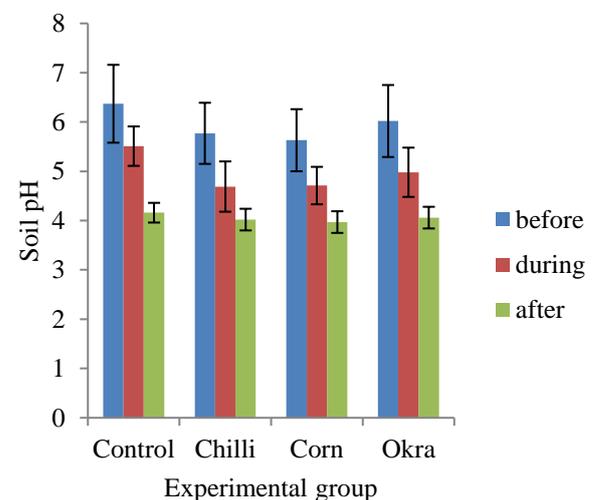


Fig.1 Soil pH for three types of short-term crops and control group



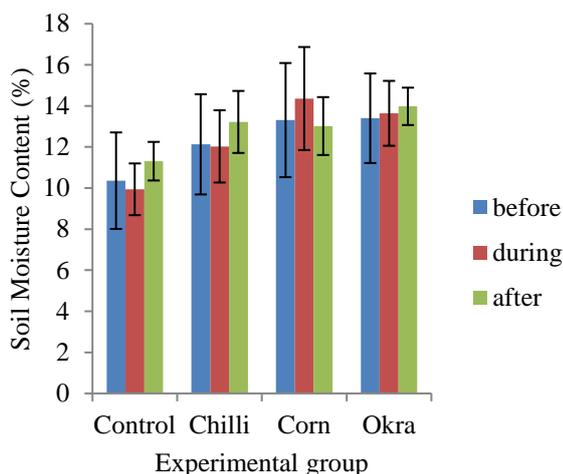


Fig. 2 Soil moisture content (%) for three types of short-term crops and control group

b) NPK Analysis (Before, During and After)

In this study, analysis using ANOVA was used to determine the value of nitrogen(N), phosphorus (P) and potassium (K) before the crops were planted, during the crops were planted and after the crops were removed from the study site. Table 2 showed the results on soil quality (NPK) in karas plantation based on the type of planted short-term crops. Based on Table 2, the analysed results showed no significant difference ($p < 0.05$) for all NPK values of all three short-term crops planted on the study site when compared to the control group

Table. 2 Soil quality (NPK) according to the type of short-term crops planted on the study site

Soil NPK	Type of short-term crops (Min ± SEM)			
	Control	Chilli	Corn	Okra
Before				
N (%)	0.60±0.10	0.38±0.06	0.33±0.05	0.42±0.04
P (mg/kg)	2.95±0.85	2.88±0.49	2.95±0.51	2.62±0.51
K(mg/kg)	216.25±7	190.43±6	196.30±5	301.25±10
During				
N (%)	0.36±0.01	0.24±0.06	0.24±0.06	0.24±0.03
P (mg/kg)	2.85±0.10	3.10±0.58	3.75±1.19	3.70±0.98
K(mg/kg)	69.29±3.2	98.40±11.	124.56±1	98.15±16.5
After				
N (%)	0.53±0.11	0.47±0.04	0.52±0.16	0.46±0.10
P (mg/kg)	3.27±0.50	3.59±0.66	3.88±1.05	3.40±0.58
K(mg/kg)	105.52±4.	134.14±3	111.95±1	183.94±32.
	11	1.11	7.85	58

Note, N=Nitrogen, P=Phosphorus, K=Potassium;
* The mean difference is significant at $p < 0.05$

Figure 3, 4 and 5 showed the mean of nitrogen (N), phosphorus (P) and potassium (K) of three types of short-term crops and control group before the crops were planted, during the crops were planted and after the crops were removed from the study site.

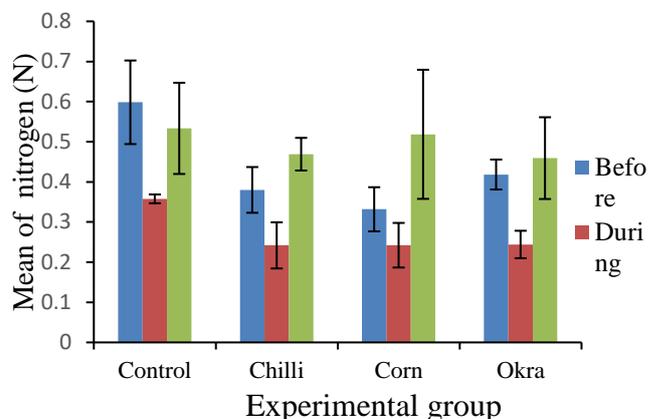


Fig. 3 The mean value of nitrogen (N) for the three types of short-term crops and control group

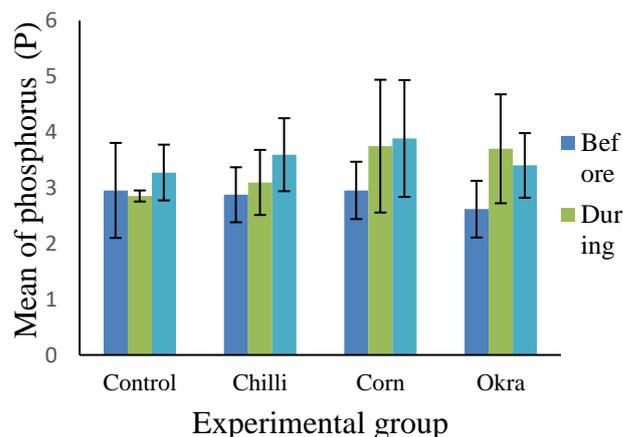


Fig. 4 The mean value of phosphorus (P) for the three types of short-term crops and control group



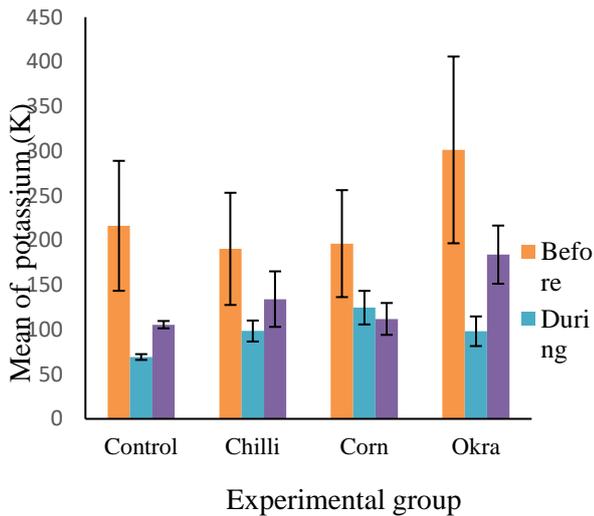


Fig. 5 The mean value of potassium (K) for the three types of short-term crops and control group

IV. DISCUSSION

a) Soil pH dan Soil Moisture Content

According to Table 1, there was no significant difference in the soil pH and soil moisture content(%) for all three types of short-term crops which are chilli, corn and okra before the crops were planted, during the crops were planted and after the crops were removed from the study site when compared to the control group.

The present findings showed that the soil pH of the study site was acidic which was below pH 7. It was also found that the soil pH value decreased (Figure 1) for all three short-term crops after the short term crops were removed from the study site. The presence of various types of short-term crops in one study area can lead to an increase in soil organic matter which causes the soil to become more acidic (Ritchie & Dolling, 1985). Soil organic matter produced by plants and animals will undergo biological decomposition process and most of the organic matter consist of plant tissues (Bot & Benites, 2005). Hence, the soil pH was found to be decreasing and acidic during and after the study was carried out. The soil pH for chilli before the crops were planted, during the crops were planted and after the crops were removed from the study site are 5.77 ± 1.51 , 4.69 ± 1.24 and 4.02 ± 0.54 respectively. Meanwhile, the soil pH for corn before the crops were planted, during the crops were planted and after the crops were removed from the study site are 5.63 ± 1.54 , 4.71 ± 0.93 and 3.97 ± 0.55 respectively. The decrease in soil pH of okra before the crops were planted, during the crops were planted and after the crops were removed from the study site are 6.02 ± 1.78 , 4.98 ± 1.23 and 4.06 ± 0.54 respectively. From the previous study by Jones and Olson-Rutz (2016), soil pH affected the presence of essential elements such as nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and molybdenum where these elements are more likely to be found in high pH value of soil, while iron, manganese, boron, copper and zinc are more abundant in low pH soil.

According to Malaysia Peninsular Forestry Department (2012), soil pH for karas plantation is suitable at pH 5.5-6.5 whereas lower soil pH value such as 4.2 and 4.3 is not suitable for the growth of karas trees. The present results depicted that the soil pH before short-term crops were planted was in a suitable range of 5.63 – 6.02 for all three short-term crops. However, soil pH has decreased during the short-term crops were planted and after the short-term crops were removed from the study site. This indicated that the presence of short-term crops in study site affected the soil pH value. Nevertheless, the growth of karas trees in terms of height, leaves count and tree circumference were not affected by the decrease of soil pH value that occurred. According to Mastuti (2016), low soil pH or slightly acidic (5.5-6.5) is very suitable for the growth of roots. Although the results showed that there was a decrease in soil pH value during the short-term crops were planted and after the short-term crops were removed from the study site, it did not affect the growth of karas trees due to the presence of high soil organic matter that can repair soil structure for tree growth (Schumann, 1999). It is found that it gave positive result to the integration of short-term crops with karas trees. Besides soil pH, soil moisture content was also measured in this study. Chilli showed almost similar percentage value (%) of soil moisture content before the crops were planted, during the crops were planted and after the crops were removed from the study site are 12.13 ± 5.98 , 12.03 ± 4.32 and 13.22 ± 3.70 respectively. Same goes to corn crops which showed not much different in percentage value (%) of soil moisture content before the crops were planted, during the crops were planted and after the crops were removed from the study site are 13.31 ± 6.81 , 14.36 ± 6.14 and 13.02 ± 3.45 respectively. Besides, okra recorded percentage value (%) of soil moisture content before the crops were planted, during the crops were planted and after the crops were removed from the study site are 13.40 ± 5.35 , 13.64 ± 3.87 and 13.98 ± 2.22 respectively. From the previous research, monoculture karas plantation or without intercropping system showed a slightly higher percentage value (%) of soil moisture content compared to the research which were $23.1 \pm 1.45\%$ and $23.8 \pm 1.6\%$ respectively at the study site in Sepang whilst in Lipis, research results showed percentage (%) of soil moisture content of about 22.5 ± 0.8 and $22. \pm 0.9\%$ (Nashriyah Mat et al., 2012). High water intake for plant growth by short-term crops caused competition between karas trees with intercropping crops to obtain water from the soil. This situation might be the reason why the soil moisture content (%) decreases when compared to previous study.

b) Nutrient Content in Soil (Nitrogen, Phosphorus, Potassium)

Table 2 shows the results of soil quality (NPK) in karas plantation according to the type of short-term crops. The analysed results found that there was no significant difference ($p < 0.05$) for all NPK values in all three short-term crops planted in the study site when compared to the control group.



However, there was a slight decrease in nitrogen value in all research plots during the short-term crops were planted (chilli, corn and okra) when compared to the nitrogen value taken before chilli, corn and okra were planted. Nevertheless, there was a slight increase in nitrogen value in all research plots after chilli, corn and okra were removed from the study site. This situation showed that the nitrogen elements in the soil were used by chilli, corn and okra for their vegetative growth especially for the growth of shoots and leaves. The findings are almost similar to the previous study by Sharma (2011) who conducted a study on *Psidium guajava* (guava). The presence of enough nitrogen in the soil is important to generate an optimum productivity by the crops (Muhumed, Jusop, Sung, Wahab & Panhwar, 2014). The decrease of nitrogen value in the soil after the short-term crops were removed from the study site may probably be due to fertiliser applied in all research plots were dissolved and carried away by rainwater to other places (Mackowiak, 2014).

Meanwhile, the phosphorus value increased when compared to the phosphorus value obtained before the short-term crops were planted except for okra's plot after the okra was removed from the study site. This condition occurred when phosphorus was used to its maximum level to produce healthier and higher quality of okra crops. Generally, phosphorus element is essential for fruit size growth (Sharma, 2011). These findings are supported by Bhende et al. (2015) which found that the presence of enough phosphorus may produce the best quality of okra while maximising the crops' productivity effectively.

The soil analysis on potassium found that there was a slight decrease of potassium value after chilli, corn and okra were removed from the study site. The decrease in the value of potassium was due to the consumption of potassium by chilli, corn and okra for the growth process until all short-term crops were harvested. Potassium is an important element for plant growth especially in carbohydrate synthesis, protein synthesis and it also acts as an agent that prevents diseases' attack on crops (Sharma, 2011). The healthy growth of short-term crops that were planted in the study site has proven that potassium is important to help all crops free from pest attack.

However, there was a slight decrease in potassium value of corn crops after the corn was removed from the study site. This situation occurred probably due to the corn crops that fully rely on potassium supplied by organic fertiliser which was applied to the soil. The potassium value kept decreasing because the corn crops have consumed the potassium from the growth stage of seedlings until the corn became matured as well as for the growth of fruit. Liaqat et al. (2018) also stated that potassium element is important for corn growth especially to produce high quality of fruit. Besides, the low content of potassium in the soil may be due to the dissolving process that occurred and the potassium was carried away to another place (Asma et al., 2011).

In this study, there were no chemical-based fertilisers applied to the study site throughout the research period. Hence, NPK elements that are needed by karas trees and short-term crops were obtained from the organic fertilisers of livestock waste that were applied at the study site before

chilli, corn and okra were planted. From the observation, it was found that intercropping crops grew healthily and free from any disease. Yildirim & Guvenc (2005) also stated that intercropping technique is more productive if compared to monoculture technique. This is because the intercropping technique helps farmers to use soil, light, water resource and nutrient optimumly and more effectively. Other than that, soil will become more fertile and potentially reduce the attack by pests (Yildirim & Guvenc, 2005).

V. CONCLUSION

The presence of intercropping crops caused the soil to become more acidic and the soil pH value reduced due to decaying process of the crop. Meanwhile, the competition for water between karas trees and short-term crops did exist and this will affect the soil moisture content at the study site. The interaction of elements in the soil especially NPK elements was at its optimum and this becomes the main catalyst for the growth of trees at the study site. Sharma (2011) concluded that the presence of enough NPK elements really affects the productivity of the crops. Not only that, the vegetative growth of trees was affected by the presence of enough nitrogen in the soil whilst phosphorus plays an important role in photosynthesis and collecting food resources (Sharma, 2011). Meanwhile, potassium acts as a catalyst in the formation of more complex materials and its function is to stimulate enzymatic activities that eventually positively affect the physical fruit growth (Sharma, 2011). In conclusion, the integration of chilli, corn and okra with karas trees did not give any negative impact to soil pH value, soil moisture content as well as NPK content in the soil. In fact, this method did not affect the overall growth of karas trees and was able to increase the growth of the trees besides allowing the farmers to earn better returns.

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Intercropping System Affect PH, Moisture Content and the Presence of Nitrogen, Phosphorus and Potassium (NPK) in Soil at Karas Plantation Area

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