

Climate Change :  
**Crop performances  
and potential**

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**PROFESSOR DR. MOHD FAUZI RAMLAN**

# Climate Change : Crop performances and potential

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## ABSTRACT

The effect of climatic change on food crops and other economic value plantation such as oil palm and rubber has received a major concern for many governmental organisations including universities researchers. The rise in CO<sub>2</sub> level that comes together with the higher temperature would certainly affect the crop performances. Since many of the crops are categorised under C<sub>3</sub> plants, early maturity resulting in lower yield would be expected. In some studies the reduction in yield is due to the photorespiration of these plants.

The global climatic change may also be a concern for many countries in the world. A report from ACOP indicated that the top ten countries such as China, USA, EU, Russia and Japan have contributed to more than half of the CO<sub>2</sub> emission in the world. Efforts to bring the CO<sub>2</sub> under control will only be seen over a long period of time. However, it has been forecasted that developing countries will certainly overtake the developed world for the CO<sub>2</sub> emission after 2015. Opening of many new areas for agricultural purposes has contributed to the increase of CO<sub>2</sub> for the developing nations.

This report covers the growth study and photosynthetic activities on several horticultural crops, forest perennials and rice. Suggestions of the possible responses on the increase of CO<sub>2</sub> are also included. In addition, a biological control using other species of bamboo to reduce the domination of buluh semantan under high voltage transmission lines is also included.

In the studies regarding growth of forest species meant for domestication purposes, the suitability of *Syzygium campanulatum* and *Hopea odorata* for beautification and landscaping plants has shown some potential. However, modifications on such forest species using growth retardants are important. The use of organic fertiliser for an environmental friendly condition is also highlighted.

Since it has been a part of the governmental policy for beautifications, the floriculture and ornamental industry has received special attentions. In the production of chrysanthemum, the industry has been trying to formulate nutrient formulation aimed for highlands and lowlands. A similar study has been done in the production of bell pepper in lowland areas. In-depth analyses on plant partitioning and yield components are highlighted.

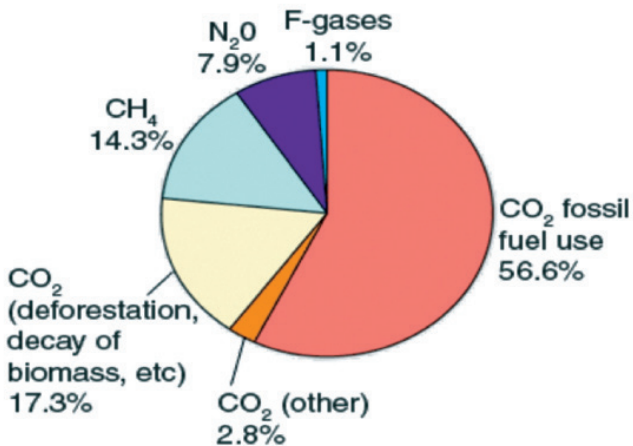
The potential of using microorganism to establish early growth of oil palm seedling has also been included in this lecture series. Such a potential was shown using microbes such as *Azospirillum* (Strain Sp7 and CCM 3863) in early establishment at nursery stage. These microbes enhanced the root development of the oil palm seedlings. In addition, the possibility to nitrogen fixation in the roots, which is similar to the association of *Rhizobium* sp. in legumes, is also highlighted.

For rice production, the issue of food security against development is being discussed. Water shortages, high temperature from global warming and crop sustainability are some of the key issues for the future of the crop. It is highlighted that water shortage would result in low tiller ability and high weed infestation. Similarly, high temperature at night would result in reduction in yield as the result in the reduction of the fertility rate of female inflorescence.

In conclusion, serious considerations should be made on the increase of carbon dioxide and its influence on the growth of many economic crops. Food security should be looked from all angles and a holistic approach towards solving this issue should be addressed.

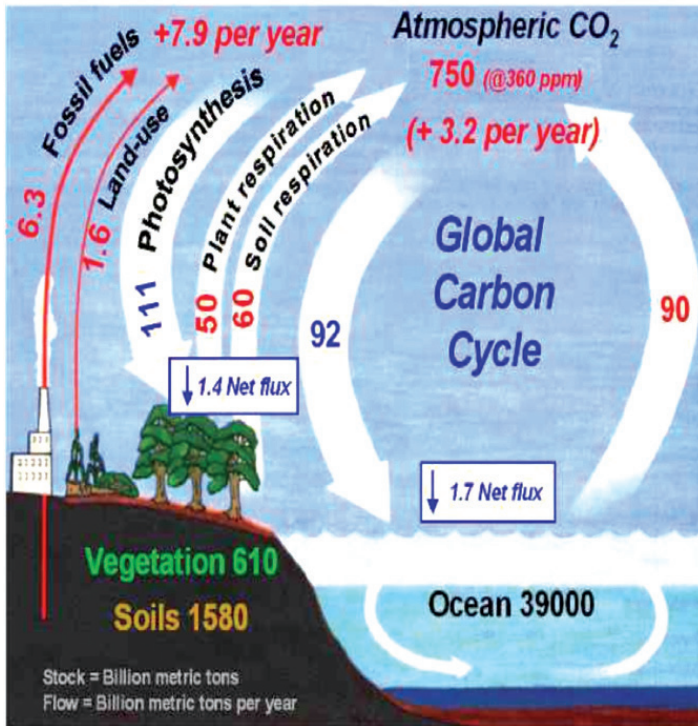
## INTRODUCTION

Carbon dioxide has been one of the important gaseous in the world. Not only has it evolved in the formation of the earth but more importantly is that carbon dioxide is the basic in providing carbon for formation of carbohydrate. It has been widely accepted that the carbon cycle is involved in our daily life. Be it from the formation of carbohydrate through photosynthesis up to the transfer of energy by detrivores to roots of the plants, carbon has always been relevant. Figure 1 shows the various kinds of greenhouse gaseous which have been related to global warming and greenhouse effects. Carbon dioxide emission from fossil consists of the largest portion of more than 50% followed by carbon dioxide release as the result of deforestation and decaying activities.



**Figure 1** Global greenhouse gas emission (source: 4<sup>th</sup>Assesment Report: Climate Change 2007: Synthesis Report)



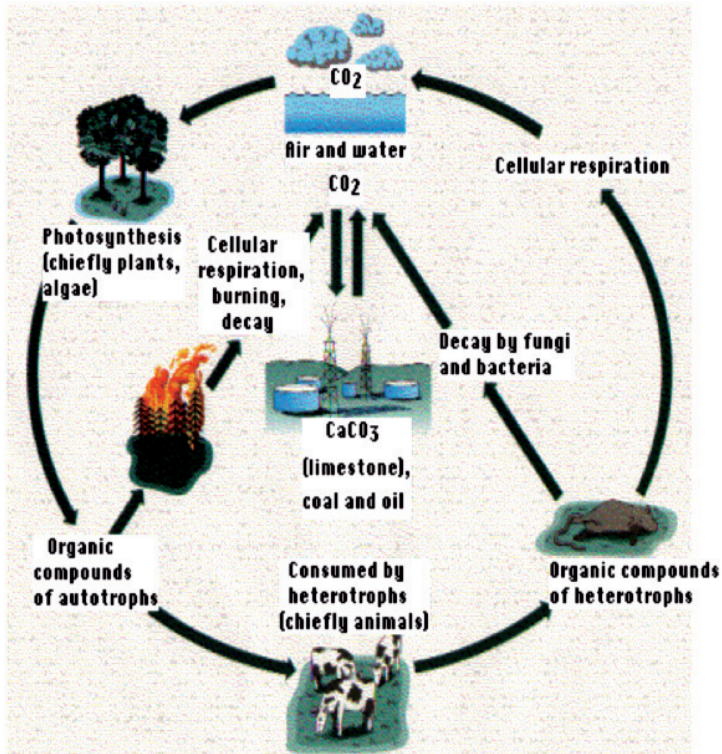


**Figure 2** An over view of carbon cycle

(Source: <http://www.carbon+cycle&hl=en&biw=1440&bih=809&prmd=imvns&tbn=isc&tbo=u&source=univ&sa=X&ei=QuitTqbwMM3HrQeQ6LHqDA&ved=0CEkQsAQ>)

Figure 2 shows a more in depth cycle of CO<sub>2</sub> cycle. Fossil fuels, land use and respiration activities contributed on the rise of carbon dioxide to the atmosphere and photosynthesis is the only activity which reverse the process where the usage of CO<sub>2</sub> and converting it to oxygen. It has already been indicated that in the figure, carbon stock or reserve in the ocean amounted to 39000 billion metric tons. There are also about 610 billion metric tons carbon stock in vegetation and about 1580 billion metric tons in the soils. Moreover, the global carbon cycle above ground through fossil fuels and land

use activities which contributed 7.9 billion metric tons per year. In addition, the atmospheric carbon dioxide through the global carbon cycle contributed an additional 3.2 billion metric tons yearly.



**Figure 3** A simplified carbon cycle

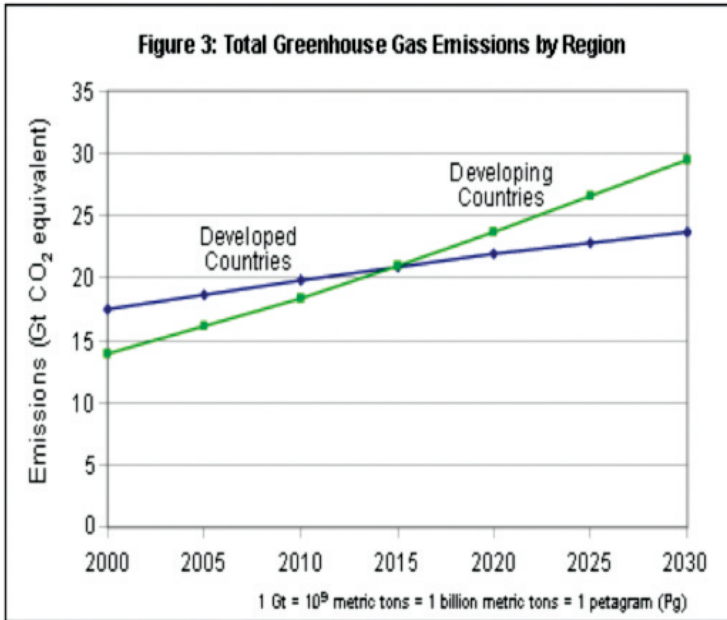
Plant physiology has always been associated with climatic change where a natural process of recycling carbon dioxide has occurred. Even though the process seems to be easy but in reality it is a complex with many variables that are involved (Figure 3). As shown in the cycle, atmospheric carbon dioxide will be fixed through photosynthesis largely by plants and algae. The organic

carbon would later be converted to organic compound of autotroph which may later returned to atmospheric CO<sub>2</sub> through cellular respiration, burning and decaying processes. If the organic carbon been consumed by heterotroph (largely animals) and later turned to atmospheric carbon through cellular respiration.

In Malaysia, government effort towards a sustainable ecosystem has received a concerted effort by many interested parties especially in the agricultural sectors. Vietmeyer (1996) has mentioned the possibilities of plantation crops such as oil palm (Malaysia), acacia (Indonesia) and vertiver (Thailand) could assist in the absorption of carbon dioxide emission in the world. However, a study made by Sapari Mat (2006) on *Acaciamangium* has shown that there is no clear cut relationship between the gas exchange capacity with growth performances and biomass accumulation in perennial forest plants.

## **MALAYSIAN AGRICULTURAL TREND**

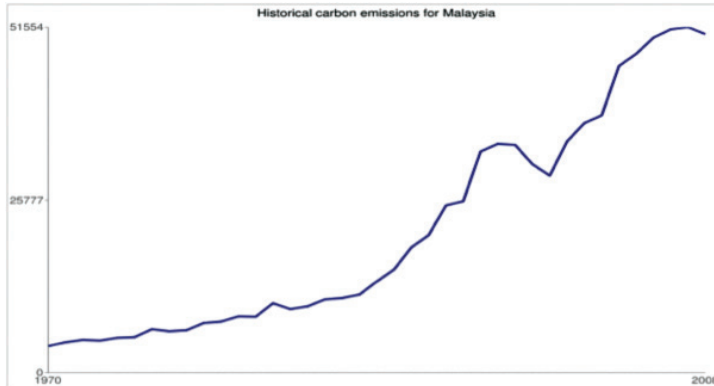
Since oil palm production has been one of the successful stories in terms of economic returns besides of the oil and gas industries, the significant edge that the country has should be protected. As data shown the trend for carbon emission in Malaysia has increase tremendously from about 4,500 metric tons in 1971 to about more than 2,000 metric tons in 2011 (predicted values; Boden et al, 2009).



**Figure 4** Projection of future greenhouse gas emissions of developed and developing countries

Figure 4 shows the trend of total greenhouse gas emissions produced by developed and developing countries. It has been forecasted that the developed countries such as the European unions and USA would eventually reduced their greenhouse gas emission by the year 2015. However, the developing countries would then overtaken by the developed countries in terms of production of total greenhouse gas emission. Such a trend in due to the concerted effort by these developed countries to enforce strict rules and later reduce the greenhouse gas emission through the public awareness programs and environmental friendly transportations. Moreover, uncontrolled activities such as the opening of new agricultural areas, heavy usage of inorganic fertilisers and the lack of understanding

on environmental issue has caused the developing countries to be higher contribution to the total greenhouse gas emission than the developed regions.



**Figure 5** Historical carbon emission for Malaysia (CDIAC)

Figure 5 shows the trend of carbon dioxide in Malaysia from 1970 until 2008. The increasing trend of carbon emission in Malaysia is due to the opening of new areas for oil palm cultivations which included clearing and burning of stumps thus making the carbon reserve becoming available. Moreover in many incidences, a large amount of areas for old rubber and cocoa has been converted to oil palm plantation.

On the environmental issues, Hartemink (2005) has highlighted that the net carbon fixation by oil palm plantation is huge and can be an equivalent of a lowland rainforest. Similarly work by Henson (1999) has estimated that the total above carbon stock of mature oil palm is about  $100 \text{ Mg ha}^{-1}$  and the above ground biomass is three to four times larger.

Besides carbon dioxide increment, food production in Malaysia has also received other issues such as reduction of water sources; the loss of fertile production area; over use of chemical fertiliser and intensified research for yielding cultivar (Fatimah Mohamed Arshad, 2011).

## **WORLD CARBON DIOXIDE EMISSION**

As the world population increases, the amount of food required to feed its population increase also but at slower phase than the rate of population increase. It has been estimated that the world population of 7 billion and the world food crisis have been addressed in many scientific meetings. It is clear that famine cases in east Africa together with the economical and political instability of the Middle East have created the situation of food security become worst.










Meanwhile, while the conversion of agricultural land into housing and other industrial activities has been actively debated by the public. The issue of food security against shelter and jobs in the industry biomass accumulation in crop production has always been associated with the gas exchange processes through photosynthesis. A report by CDIAC (Carbon dioxide information analysis center) has indicated that the world carbon dioxide emission is on the increase as the result of burning fossil fuels and cement manufacturer.

Increase of the green house gaseous not only has resulted in higher carbon dioxide but also increase in higher temperature resulting as the result of the increase of respiration rates. In the case of the expansion of plantation crops namely oil palm, it has only utilised lands formerly used to grow rubber, cocoa or coconut (APOC, 2003). Studies have shown that areas planted by oil palm are more effective for carbon sink-area of dry mater as compared to a normal rainforest. It has been estimated that an

oil palm plantation is capable to assimilate about 44 tones of dry matter/ha/year as compared to 25.7 tones of dry matter/ha/year assimilated by rain forest. This fact shows that the efficiency of oil palm crop to have high leaf area indices which allows them to have better photosynthetic efficiency. The final result would be that such plantations crops would produce more oxygen to the air and absorb more CO<sub>2</sub> (APOC, 2003).

Table 1 shows the list of countries that emit the most carbon dioxide in the world. It is a disturbing scene with China, USA, European Union, India, Russia and Japan as amongst the top countries where carbon dioxide was emitted to the atmosphere. In fact it has been commented that the top 10 countries where carbon dioxide emission is at the highest with the contribution of 67.07%. In the Southeast Asia region, the highest carbon dioxide emitter in the region is Indonesia followed by Thailand and Malaysia. As for Malaysia, human activities contributed the most causal for the emission of carbon dioxide gas. Activities such as burning of old stumps, opening of new areas for agricultural purposes and the release of methane gaseous during the oil and natural gas production caused the conditions to be worsened. Moreover, the use of inorganic fertiliser especially in rice production areas has increased the potential of greenhouse effect (Figure 6). On the other hand, with a concrete effort from the government, the non-government organisations (NGO's) and the public, Singapore experienced only 32,295 thousands of metric tones or 0.11% of the global total gas emission. Such an effort should be applied and enforced in other countries of the Southeast Asian regions.

**Table 1** World CO<sub>2</sub> emission by the countries as reported by APOC

Rank	Country	Annual CO <sub>2</sub> emissions (Metric tones)	Percentage
	<i>World</i>	29,888,121	100%
1.	 <a href="#">China</a> <sup>[10]</sup>	7,031,916	23.33%
2.	 <a href="#">United States</a>	5,461,014	18.11%
3.	 <a href="#">India</a>	1,742,698	5.78%
4.	 <a href="#">Russia</a>	1,708,653	5.67%
5.	 <a href="#">Japan</a>	1,208,163	4.01%
6.	 <a href="#">Germany</a>	786,660	2.61%
7.	 <a href="#">Canada</a>	544,091	1.80%
8.	 <a href="#">Iran</a>	538,404	1.79%
9.	 <a href="#">United Kingdom</a>	522,856	1.73%
10.	 <a href="#">South Korea</a>	509,170	1.69%
15.	 <a href="#">Indonesia</a>	406,029	1.35%
22.	 <a href="#">Thailand</a>	285,733	0.95%
73.	 <a href="#">Singapore</a>	32,295	0.11%
27.	 <a href="#">Malaysia</a>	208,267	0.69%





**Figure 6** A common view of a rice production area in Sekinchan, Selangor

## STRATEGIC IMPORTANCE

Since there are only few studies on the gas exchange capacity on tropical crops, it is therefore a great importance that these crops are to be considered for their ability to fix carbon dioxide. Not only that they are perennials and are able to live for a long period (more than 25 years), their capacity to convert  $\text{CO}_2$  to  $\text{O}_2$  must not be underestimated. Table 2 shows the capacity of photosynthetic potential of several perennials and oil palm crops. The result showed that oil palm has a high carbon fixation as compared to other fruit trees and some forest species. Therefore, the ability of oil palm to

convert the atmospheric carbon dioxide to oxygen as compared to other trees is better. It is an interesting finding as such oil palm crops with the C<sub>3</sub> ability would be able to fix atmospheric carbon dioxide during photosynthesis.

**Table 2** The gas exchange capacity for some perennials species and oil palm crops

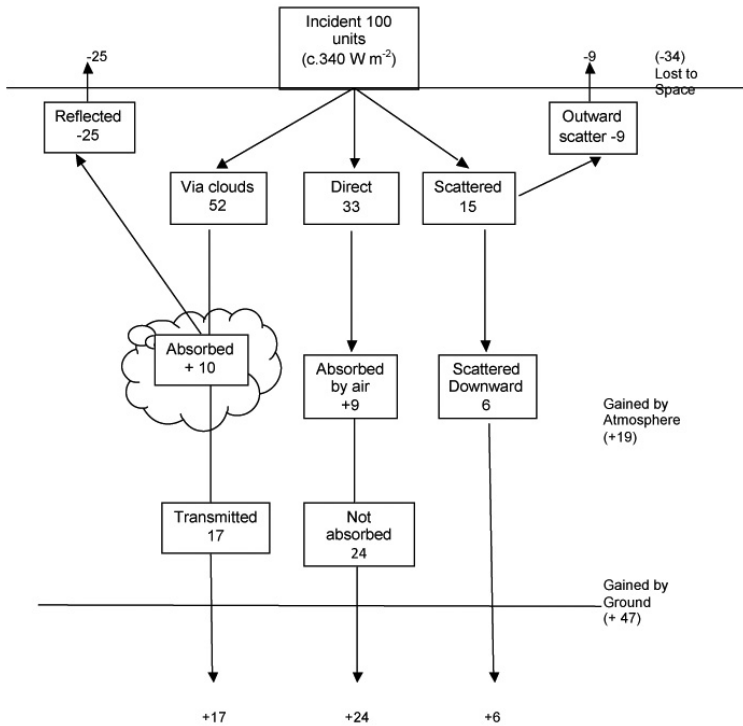
Crops	Photosynthesis capacity (umol/m <sup>2</sup> /s)	References
Oil palm	20 -24	Corley & Tinker (2003)
Durian	6-14	Ramlan <i>et al</i> (1996)
Mangosteen	3	Ramlan <i>et al</i> (1992); (Adiwirman <i>et al</i> , 2001)
<i>Hopea odorata</i>	8-11	Ahmad Azaruddin (2007)
<i>Acacia mangium</i>	10-14	Sapari Mat (2008)
<i>Syzygium campanulatum</i>	2-4	Ahmad Nazaruddin (2006)

Even though that the perennial fruit trees may not have a high capacity to fix CO<sub>2</sub>, but over a number of years, their contribution as carbon sequestration is most likely to be high. Unlike in economic plantation crops such as oil palm, fruit trees possess a low capacity for photosynthesis. However, the total sum of canopy photosynthesis may contribute to a larger amount CO<sub>2</sub> fixed.

In a study addressed by Squire (1990), in most cases  $C_3$  plants such as rice, oil palm and legumes would have their maximum growth rate of 35 to 40 g/m/day as compared to  $C_4$  plants of maximum growth rate of 50-55 g/m/day. However, the total dry matter production would actually depend on the longevity of the foliage.

The passage of solar radiation that travelled from the sun until it reached the earth surface was discussed by Bannister (1976). The integrated flux density of solar rays will undergo several processes of reflected, refracted and scattered before finally reaching the earth surface (Figure 7). A theoretical relationship as described by Bannister (1976) involved sun light being scattered and absorbed by clouds and would only result in 47% reaching the ground. Later it was discussed that only four percent can be used by the plant due to the differences in wavelength and reaching the ground when the crops were not ready. As such the process of harvesting the light energy is critical for the plants, the plant pigments responsible for the process are also vital. For example, chlorophyll is one of the major pigments in absorbing sunlight at the wavelength of 430nm and 662nm.

Figure 7 also shows that about 34% of the incident light from the sun is either being reflected back to the atmosphere or scattered outward into outer space. It is also interesting that about 19% of the sunlight is further gained by the atmosphere leaving about 47% which is gained by the ground.



**Figure 7** The passage of solar radiation through the atmosphere scattered before reaching to the earth surface

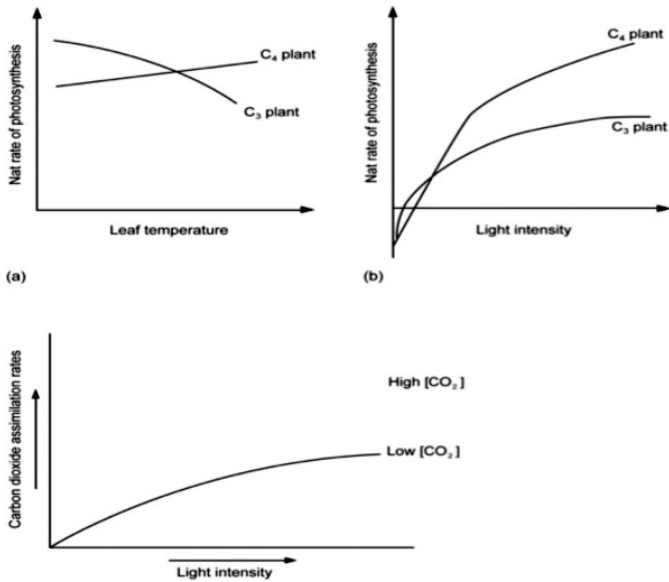
(Average annual values for the Northern Hemisphere – after Gates 1962).

## GROWTH STUDY

Growth can be defined as irreversible processes of increase in numbers, weights and sizes (Hunt, 1982). This definition can be associated with the accumulation of carbohydrate as the result of carbonfixation. Thus, net growth can actually be the relationship of photosynthesis minus respiration in plants.

In terms of distribution of the photosynthetic assay, plant partitioning is used to indicate the dry matter distribution of a crop. A study using bell pepper grown under rain shelter protection system with different fertiliser programme has shown that under high CO<sub>2</sub>, most of the C<sub>3</sub> plants would experience a high photosynthetic rate as the RUBP oxygenase change its function to RUBP carboxylase. As the result of higher availability of CO<sub>2</sub>, the photosynthetic activities also increase in the leaves. At the same, the rate of respiration also increases. As the result, plants are predicted to reach earlier maturity. These findings suggest that the breeding programmes should look at inbred lines which are high in yield potential under high CO<sub>2</sub> concentration.

Figure 8 shows a normal pattern for relative rates of C<sub>3</sub> and C<sub>4</sub> as influenced by temperature and light intensity. Principally, the C<sub>4</sub> plants are physiologically active with higher photosynthesis activities for hot dry and high light conditions. Moreover photorespiration does not occur in C<sub>4</sub> plants. Therefore, C<sub>4</sub> plants such as corn and sugar cane would produce a good yield in hot and bright light conditions. Since many of our economic and food crops such as oil palm, rubber, rice and capsicum are categorised as C<sub>3</sub> plants, measures have to be made in selection of new hybrids, which are able to produce high yield under high carbon dioxide and temperature conditions.



**Figure 8** A normal pattern for temperature and light response curve for C<sub>3</sub> and C<sub>4</sub> plants.

However, normal greenhouse simulation indicates that increase of CO<sub>2</sub> alone does not represent the true picture. Increase in CO<sub>2</sub> is followed by the increase in atmospheric temperature. It has been clearly demonstrated that in many C<sub>3</sub> plants the increase in temperature would reduce the photosynthetic capacity of C<sub>3</sub> plants in which one of the true explanation is due to the temperature sensitivity of certain enzymes (Acquaah, 2002). Similarly, a report by Cave et al (1981) highlighted that in the case of clover plants, lower chlorophyll a:b ratio has been found in the high CO<sub>2</sub>. The result explained the chlorotic appearance as the result of a decrease in chlorophyll content per dry weight. They also explained about

the possibility of large starch grains and starch accumulation which altered the normal function of normal chloroplast.

Increase in temperature not only limited to the reduction of certain enzymes but also in reduction of fertility in female inflorescence. Many studies conducted in a rice research institute in Philippines have indicated that an increase of night temperature of 1°C would reduce the rice yield as much as 10% (IRRI, 2011). In addition, increase in temperature would decrease the percentage of germination of many tropical crops. Squire (1990) indicated that a temperature range of between 15°C to 40°C is suitable for the seed germination of most plants.

There are many interest groups and scientists who would genetically engineered super rice to have C<sub>4</sub> traits that may increase the photosynthetic ability (Zhu et al., 2010). The C<sub>4</sub> rice project would bring the best of genetic engineering in crop science where it will involve genes associated with photosynthetic activities in rice. Eventhough the result may be possible theoretically, the reality may not happen overnight.

## **PLANT PARTITIONING**

Monitoring the distribution of growth pattern over time would indicate the significant stage for vegetative, reproductive and maturity and senescence. For example, a typical growth of bell pepper plant indicated there is a distinct change in terms of dry weight distribution over vegetative, reproduction and senescence. Since by definition partitioning is involved in the redistribution assimilates throughout plant growth. Norhanani Ahmad (2009) has indicated that this distribution is consistent even though during growth condition. In all conditions, the total dry weight, leaf and root dry weight after 28 days are highly influenced by the availability of N and K. In one of her studies, the vegetative growth of bell

pepper plants total dry weight increased at faster rate and later at the plateau stage at 30 days after transplanting.

**Table 3** Total dry weight, total fruit weight and number of fruit per plant for Bell pepper grown in three different nutrient solutions. Data were collected at 124 day after transplanting

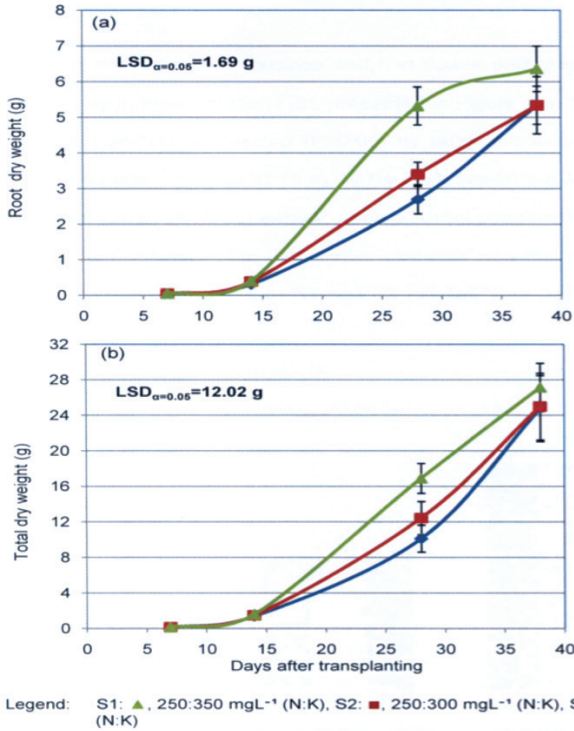
<b>N:K (mg/L)</b>	<b>Total dry weight (g)</b>	<b>Total fruit weight (g/plant)</b>	<b>Number of fruit per plant</b>
250:350	274.16	1841.00	55
250:300	259.21	1565.30	50
200:300	245.71	1432.10	46

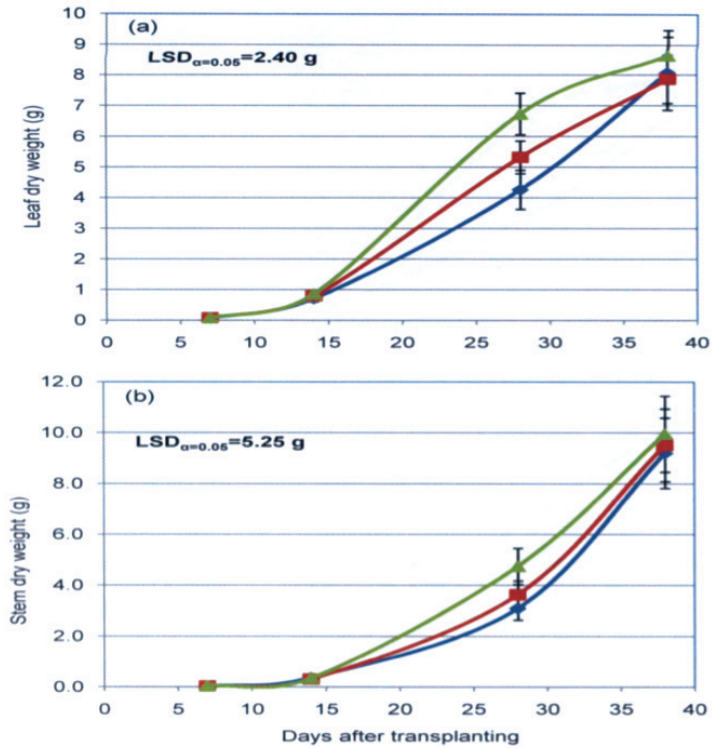
As indicated by Acquah (2002) the distribution of dry weight is due to the demand sink tissues. These sink tissues are found in regions with rapid growth and metabolism in plants. Similarly, as the photosynthesis is regulated by the demand sink activity of the plants, the rate is slower when leaves are younger and all the pigments are fully developed. It is not until fully expanded source leaves where the photosynthates are produced at maximum.

Figure 9 shows the pattern of dry weight distribution of roots, stems, leaves and total dry weight for bell pepper plants grown under different nutritional levels. It has been said that partitioning manifests the change in plant morphology during the growth season. During the vegetative growth stage, the main objective is to establish good growth which is vital during flowering and fruiting stage (reproductive stage). The nutrient components of nitrogen and potassium are important for development of bell pepper as shown during the study. The change in the morphological attribute from vegetative to reproductive stage would depend on factors



such as water availability and intercepted sunlight. As such the root system and canopy extension would represent the crops for maximal development.





**Figure 9** Plant partitioning of bell pepper plants during vegetative growth stage grown under different nutritional concentration level

The results from the study indicated that during the vegetative growth of bell pepper the nutrient level of nitrogen and potassium would have a high impact on the development. At such nitrogen:potassium ratio of 250:350 mg/L would have a faster rate of total dry weight production. It is therefore important to have these nutrients so that better plants leading to higher yields can be achieved (Table 3). It is also noted that the N:K ratio would also give the highest fruit weight and fruit numbers. These data would

indicate the sink capacity of the bell pepper plants with regards to nutrition status. It is therefore important to know the re-mobilisation processes from the source (leaves) to the sink (fruits)

Similar results of nitrogen and potassium association on growth development are also found by Squire (1990) where in Peninsula Malaysia, the dry matter/ intercepted radiation ratio is positively correlated with potassium content for oil palm trees. Moreover, studies in Australia have showed leaf nitrogen content on maize and sorghum has a direct on the light intercepted and the total dry matter production.

## **USAGE AND POTENTIAL USE OF PLANT GROWTH AND PARTITIONING**

### **Landscape**

As the awareness for beautification and landscape is on the increase, the knowledge of global and climatic change has also received an overwhelming support from the government and the public. Of late, the uses of native forest species for landscape plants are on the increase. In many of the housing areas and recreational parks, newly introduced trees are planted to speed the establishment of the areas (Ramlan *et al.*,2000). Therefore, the ability of perennial forest plants to fix CO<sub>2</sub> in the natural process of photosynthesis need to be studied. In a study by Ahmad Nazarudin (2006), the use of *Syzygium campanulatum* as one of the landscaping plants has shown to benefit not only the municipal and public but also leads to extensive study by the Malaysian Forest Research Institute (FRIM). The only problem with *Syzygium* is that the tree can be as tall as 8 meter at maturity (Figure 9a). Therefore, efforts need to reduce the plant height using growth retardant is important.

In the study by Ahmad Nazaruddin (2006), the trees treated with growth retardants are smaller as the shown in Figure 10b. The micrograph image is further done and the result is highlighted in Figure 10c. It is clearly seen that the growth retardant affected the arrangement of the cells in plant leaf. As the result, the palisade and spongy mesophyll cells are tightly packed due to the reduction of leaf size. As such the palisade mesophyll cells are thicker for the trees applied with growth retardant. There is however, no significant difference for leaf photosynthetic ability as a result of the application. This research finding would explore the use of growth retardant on many perennial forest species to be planted as ornamental landscape sources. It assists the Town and Country Planning Department to achieve the national target of twenty million trees to be planted by the year 2020.

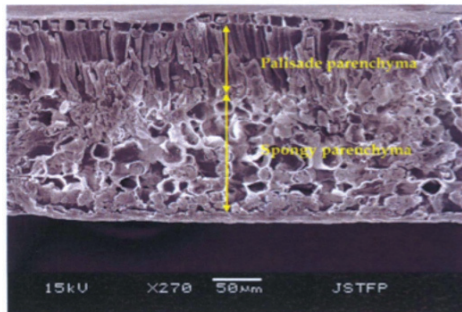
Studies on the domestications and fertiliser requirements on Merawan Siput Jantan (*Hopea odorata*) have also showed some promises (Ahmad Azharuddin, 2007). This species is not only being used as the wind-breakers plants for many locations in the North-South PLUS highways but is also used as a buffer to reduce erosions in many parts of the country. Physiologically, *Hopea odorata* is able to fix natural carbon dioxide through photosynthetic actions better than *Syzygium canipulatum* (Table 2). Therefore, in the process of urbanisation, domestication of some native trees may provide some physio-ecological balance. Moreover, the presence of these trees would certainly improve the aesthetic value of the areas.



(a)



(b)



(c)

**Figure 10** *Syzygium campanulatum* at (a) maturity, (b) dwarf using growth retardant and (c) the micrograph image of leaf lamina treated with growth retardant

## **Nutrient Formulation for Chrysanthemum Production**

Since Malaysian government initiatives on the growth of landscaping industries and the demand for floriculture and horticultural crops is on the increase, especially with the development of many landmarks such as KLIA airport, Putrajaya and Cyberjaya. Even though the Malaysian government has made a lot of efforts, there are still many issues on the production of these high-value ornamental crops. For example, local productions of chrysanthemum on highlands are still non-environmental friendly. Studies conducted by Ramlan *et al* (2000) and Siti Aishah *et al* (2001), suggested on the use of nutrient solution for the production of chrysanthemum for Malaysian highlands.

Our studies have indicated that essential nutrients such as ammonium-nitrate nitrogen ratio and nitrogen potassium ration have shown to affect the growth and longevity of cut chrysanthemum. In addition, the role of calcium on storage life of cut flower has also showed success. Since calcium is an essential component in cell wall formation, it has also been involved in the cell membrane integrity (Siti Aishah *et al*, 2000).

## **Biological Control**

The biological control involves the reduction of pest population by natural enemies with the usage of control agents such as predators, parasitoids and pathogen. In one of our study, the use of slow growth bamboo species has been introduced to reduce a further invasion of predominating species. As such a more systematic and sustainable approach is used to suppress the dominating bamboo species. The approach not only provides solution for a long term by having a natural enemy to the growth-aggressive bamboo cultivar but also can be a cost effective over a long period of time. It is only natural that

the biological approach on bamboo is only for the survival of the fittest as the natural competition occurs for space, light and nutrient. In one of our studies which involved the reduction of aggressive bamboo (buluh semantan) using other bamboo species showed that the introduction of buluh siam would actually reduce the invasion of buluh semantan especially under high voltage transmission line.

Studies conducted in Genting Highlands, Pahang and Cenderiang, Perak have indicated that planting another type of bamboo species such as Buluh Siam and Buluh Botol can reduce the dominations of Buluh Semantan. These slow growing bamboo species would significantly reduce the maintaining cost of vegetation under the national grid transmission lines. The overall cost benefit comparisons have shown that over a period of 10 years, it is economical for biological control to be of the use for the control of Buluh Semantan. Table 4 shows the growth rates of measured under high voltage transmission lines.

**Table 4** Growth comparisons between bamboo species grown under high voltage transmission power lines in Genting Highland and Cenderiang

<b>Bamboo species</b>	<b>Relative growth rate (cm/cm/day)</b>
Buluh Semantan	0.015*a
Buluh Siam	0.018 a
Buluh Botol	0.011 c

\* letters not follow by the same letters mean they are statistically significant at p=0.05

## **Microbes**

The use of microorganisms in plant growth has been acknowledged. In one of our studies using several microbes such as *Azospirillum* (strain Sp 7 and CCM 3863) on the growth of oil palm plantlets at nursery stage have indicated a lot of potential (Amir Hamzah et al, 2006). Such microorganisms are inoculated to the oil palm plantlets and their growth is monitored.

Amongst the significant advantage of these microbes is providing a good rooting system for the plants. In one of our studies involving young oil palm seedlings, root formation is better when microbes are inoculated. In addition, some of these microbes are also able to fix nitrogen, which is one of the important nutrients for oil palm. It is therefore said that *Azospirillum* (Sp7 and CCM 3863) has a great potential to be potential biofertiliser and bioenhancer for an early growth of oil palm plantlets at nursery stage. This study would certainly provide an alternative of using inorganic nitrogen for the growth of food crops.

## **Rice Production**

Since food security is one of the major topics currently being discussed in Malaysia, rice production has been receiving one of the major focuses again. Many reports have highlighted the status of rice production in Malaysia (Mon and Chang, 2008; Mohd Razi Ismail, 2011). Studies on the effect of water stress on grain filling period on rice production are also documented (Yang *et al*, 2010; Yang & Zhang, 2010). These studies indicated the severity of environmental stress such as water availability; nutrient deficiencies and temperature increase on rice production (Figure 11). The effect on the shortage of water has shown a great concern especially in Malaysia on the growth and tillering abilities of the rice plants. Water



shortage would also mean that a higher chance of weeds infestations resulting in lower rice production per unit area is also a possibility. Thus, increase in the cost of production for weed control is needed. High night temperature is also a great concern for rice producers. With the global and climatic change issue addressed, an increase of 1°C night temperature would lead to a reduction in yield as much as ten percent. The main reason is due to the reduction of fertility rate for the female inflorescence.

The issue of global warming and greenhouse gaseous does not only focused on high night temperature but also in the release of methane gas to the air. Since rice requires a high nitrogen fertiliser, the issue of high methane being released should also be addressed.



**Figure 11** An irrigation channel providing essential water to the rice plants in Sekinchan, Selangor.

## CONCLUSION

In many efforts that the Malaysian government have introduced such as the National Economic Transformation Plan (ETP), National Agriculture Policy 3 (NAP3), National Green Policy and National Food Security, they fall within the scope of food production and their sustainability. Efforts such as increasing productivity in rice production and sustaining the oil palm have been addressed in food security. However, international pressure of global climatic change has seen some resistance in these agricultural crops. Eventhough the government has committed to achieve 90% of self-sufficiency level by the year 2015 for rice production, the country has yet to show its sustainability plan.

The challenge faced by researchers and the policy makers in the food industry in Malaysia is to deal with uncertainties resulting from global climatic change (increase of CO<sub>2</sub> levels together with higher temperature) and to be able to sustain the production to fulfill the demand economically, socially and also politically.

## REFERENCES

- Ahmad Azaruddin Mohd Noor. (2007). Effects of different fertilizer regimes on the growth of merawansiputjantan (*Hopea odorata*) for urban landscape. MSc Thesis UPM.159 pp.
- Ahmad NazarudinMohd Roseli.2006.Effects of paclobutrazol and uniconazole on the growth and development of K. MSc Thesis UPM.142 pp.
- Acquaah, G., 2002. Principles of crop production.Theory, techniques and technology. Prentice Hall. 460pp.
- Amer H. G., Shamsudin Z.H., Halimi M.S., Ramlan, M.F. and Marziah, M. (2001). Effects of *Azospirillum* inoculation on N<sub>2</sub> Fixation and growth of oil palm plantlets at nursery stage. *Journal of Oil Palm Research*, 13(1), 42-49

- APOC, 2003. Palm oil. Your vegetable oil for better health. APOC. [www.americanpalmoil.com/environmental.html](http://www.americanpalmoil.com/environmental.html)
- Adiwirman, I., Mohd. Razi, I., Mohd Ridzwan, H., Masri, M., Fauzi, R. (2001). Increase survival of drought mangosteen by hydrogel polymer incorporation. *Transaction of the Malaysian Society of Plant Physiology*, 10, 79-81.
- Bannister, P., (1976). Introduction to physiological plant ecology. Blackwell Publishing 272pp.
- Boden T., Marland G., Andres R.J., (2009). Global CO<sub>2</sub> emission from fossil-fuel burning, cement manufacture and gas flaring: 1751-2006. Carbon Dioxide Analysis Center, Oak Ridge National Laboratory; Oak Ridge, Tennessee. Doi 10.3334/CDIAC/00001.
- Cave, G., Tolley, L.C., Strain, B.R. 1981. Effect of carbon dioxide enrichment on chlorophyll content, starch content and starch grain structure in *Trifolium subterraneum* leaves. *Physiologia Plantarum* 51(2), 171-174.
- Fatimah Mohamed Arshad. (2010). *Green Revolution II or Doubly Green Revolution. Options*, 15(2), 1-2.
- Hartemink, A.E., 2005. Plantation agriculture in the tropics: Environmental Issues. *Outlook on Agriculture*, 34(1): 11-21.
- Henson, I.E. (1999). Comparative physiology of oil palm and tropical rain forest. In Singh, G. Huan, L.K., Leng, T., and Kow, D., (eds) Oil palm and the environment – A Malaysia perspective, Malaysian Oil Palm Growers Council, Kuala Lumpur , pp 9-39.
- Hunt, R. (1982). Plant growth curves. The functional approach to plant growth analysis. Edward Arnold. London. 248 pp.
- International Rice Research Institute. 2011. IRRI Bulletin.
- Mohd Razi Ismail. (2011). Managing plant stress: a challenge for food security. Inaugural lecture series. UPM.
- Mon, K.L., and Chang, C.M. (2008). The impact of drought and flood on paddy cultivation in Muda Irrigation Scheme. 13<sup>th</sup> Conferenec on Irrigation and Drainage (13<sup>th</sup> MANCO), Kota Kinabalu, 2-3 Feb 2008.

- Norhanani Ahmad, (2009). Effects of Nand K concentration o nutrient take, photosynthetic capacity and growth of bell pepper grown under rain shelter in the low lands. MSc Thesis UPM.135 pp.
- Ramlan, M.F., Mahmud, T.M.M., Hasan, B.M., and Karim, M.Z. (1992). Studies on photosynthesis on young mangosteen plants grown under several growth conditions. *Acta Horticultura,e* 321, 482-489.
- Ramlan, M.F., Mamat, A.S., SitiAishah, H., and Jusoh, R. (1996) Photosynthesis capacity of seven durian grown under natural conditions. *Proceedings: International conference on tropical fruits*. Kuala Lumpur, Malaysia. 23-26 July 1996. 126-136.
- Ramlan, M.F., T.M.M. Mahmud, Sayed Ahmad Fuad, Z. Ashaari, A, Mohamed, H.Sahri and J. Talib. (2001). Eradication of bamboo under high voltage transmission line. UPM Research Report 2001. Faculty of Agriculture. 25.
- Ramlan, M.F., Leng, E.Y., Siti Aishah, H., Mahmud, T.M. and Awang, M.Y. (2000). Evaluations on nitrogen concentrations on the vegetative growth period of two chrysanthemum varieties. *Agro-Search*, 7(1), 6-10.
- Ramlan, M.F., Mustafa, K.M.S. and Siti Aishah, H. (2000). Physio-ecological evaluations of several ornamental plants under natural conditions. *Agro-Search*, 7(2), 8-10.
- Sapari Mat, (2008). Growth and photosynthetic efficiency of *Acacia mangium* and *Acacia aulacocarpa* Cunn Ex. Benth multiple leaedered trees.MSc Thesis UPM.119 pp.
- Siti Aisah, H., Malik, A.M., Ramlan, M.F., and Mahmud, T.M.M. (2001). Nitrogen and calcium nutrition for lowland chrysanthemums. UPM research Report 2001: Faculty of Agriculture. Pg 49-50
- Squire, R.S. (1990). The physiology of tropical crop production. CAB Intenational. 236 pp.
- Vietmeyer, N. (1996). New crops: Solutions for global problems. P. 2-8. In J. Janick (eds). Progress in new crops ASHS Press, Alexandria, VA.

- Yang, J., Zhang, J., Wang, Z., Zhu, Q and Wang, W. (2001). Hormonal changes in the grains of rice subjected to water stress during grain filling. *Plant Physiology* 127, 315-323.
- Yang, J., and Zhang, J., (2010). Crop management techniques to enhance harvest index in rice. *Journal of Experimental Botany*, 61, 3177-3189.
- Zhu, X.G., Long, S.P. and Ort D.R. (2010). Improving photosynthetic efficiency for greater yield. *Annual Review Plant Biology*, 61, 235-262.

## **BIBLIOGRAPHY**

**Mohd Fauzi bin Ramlan** was born in Kota Tinggi, Johor, Malaysia on October 15<sup>th</sup>, 1960. He received his primary education in Sekolah Rendah Kebangsaan Bukit Lintang, Kota Tinggi, Johore. He was later offered a place in one of the top secondary boarding schools in the country, Sekolah Datuk Abdul Razak, Seremban, Negeri Sembilan from 1973 – 1977.

Based on his academic achievements during the Malaysian Certificate of Education Examination (MCE), he won a place at Universiti Pertanian Malaysia (currently known as Universiti Putra Malaysia) where he graduated with a Diploma in Agriculture in 1981. He was later offered a scholarship to go abroad to further his studies. He accepted the offer and went to Iowa State University, Ames Iowa, USA for his Bachelor of Science Degree (1981 – 1983), and later to Louisiana State University, Baton Rouge, Louisiana for Master of Science Degree (1983 – 1985). Upon his return to Malaysia, he joined Universiti Pertanian Malaysia as a lecturer at the Department of Agronomy and Horticulture, Faculty of Agriculture in April 1986.

His deep interest in plant physiology brought him to Japan under the Colombo Plan Scholarship, where he was trained at the University of The Ryukyus, Okinawa, Japan in 1987. Upon returning from Japan in 1988, he married Juradah Abu Bakar and the couple has since been blessed with three children (two daughters and a son).

In recognition of his involvement in teaching and research, UPM granted him a scholarship to undertake his postgraduate study at the University of York, UK in 1991. He completed his Ph.D. in 1994, and resumed his appointment as a lecturer at the Department of Crop Science, UPM.

As a lecturer in the department, Mohd Fauzi Ramlan is involved

in teaching undergraduate as well as postgraduate courses. He was the coordinator for two courses in plant physiology and assisted in three other courses related to plant growth analysis and photosynthesis. He was also one of the resource persons for the MSc. Programme in Plantation Management where he has been identified as a crop eco-physiologist. Since 1986, he has supervised 52 final-year undergraduate research projects, and 24 postgraduate students (including 9 Ph.D. students of which 2 as the major supervisor). In addition, he also served in the major supervisory committees of 4 Japanese students from Saga University, Japan under the student exchange programme.

As for research, he has undertaken 13 research projects since 1986, in which he received grants from Malaysian government through the Intensified Research on Priority Areas (IRPA), National Electricity Board (TNBR), British Council (CHICHE) and an equipment grant from the Global Change & Terrestrial Ecosystem (GCTE), based in Australia. He has published in refereed journals and presented his findings in several scientific conferences worldwide. He was the head of two areas classified as priority research projects in estimating the photosynthetic capacity of selected vegetable aiming specifically on water and nutrients requirement; and, estimation of light harvesting mechanism of local rice varieties. He had also been involved in 9 consultancy projects where in 6 of the projects, he was the head of project.

Mohd Fauzi Ramlan is also active in co-curriculum activities in the University and professional societies. He was formerly the college master in one of the fourteen residential colleges in UPM, where his commitment in developing the younger generation has been highlighted. He was also the chairperson at the college master council of the university for two terms. As the head of college, he was the main person responsible in designing development and

academic achievements of students. He is also a member of several scientific organisations such as the Malaysian Society of Plant Physiology (MSPP), Malaysian Society for Horticultural Science (MSHS) and a life member of Agriculture Institute of Malaysia (AIM).

In acknowledgement of his contribution to academic and research excellence, involvement in students' activities and societies, the University (UPM) awarded him Anugerah Khidmat Cemerlang (Excellent Service Award) in 1996, 1999, 2000 and 2006. His involvement in research has also granted him two Bronze Medals in Research exhibitions in the year 2002 and a gold medal from the Malaysian Society of Plant Physiology. He was also conferred by His Majesty Seri Paduka Yang Di Pertuan Agung a medal of Johan Setia Mahkota (J.S.M) in 2010.

From 2006 to 2010, Mohd Fauzi Ramlan had been seconded to the Ministry of Higher Education (MOHE) as the Director of Student Affair and Student Development. His job involved in administering four units. These units were related to developing younger generations of Malaysians citizen in executing the government's hope for the future generation. These units were the students affairs unit, Malaysian student department for the student studying abroad (MSD is having 12 offices abroad), Sport unit and the international student affair unit. As the director of the division, he traveled abroad and making connection with various universities and prospect employers for Malaysian students abroad in countries such as USA, Canada, India and Middle East. As the person involved with International Students, Mohd Fauzi Ramlan is also in frequent contact with embassies students are studying in Malaysia. Currently, there are about 35,000 international students studying in Malaysia and the number is estimated to be 100,000



by 2010.

By the middle of 2010, he was promoted by the Ministry of Higher Education to be the Deputy Vice Chancellor (Student Affair and Alumni) at Universiti Putra Malaysia. He is responsible in assisting the Vice Chancellor in student soft skills, employability of graduates and endowment fund from the alumni. Currently, he is also involved in several consultancy projects with the Government of Aceh, Indonesia. Recently, he is one of the team members in the Cambodia, Myanmar, Laos and Vietnam (CMLV) projects financed by the Ministry of Higher Education (MOHE). Locally, he is one of the resource persons working together with GABEM, an NGO's for developing entrepreneurial skills amongst graduates. He is also the chairperson in Majlis Kepimpinan dan Latihan Universiti Malaysia

(MAKLUM) where students' leadership is addressed.

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