Climate Change : Crop performances and potential


PROFESSOR DR. MOHD FAUZI RAMLAN

Climate Change :
Crop performances and potential

PROFESSOR DR MOHD FAUZI RAMLAN
Dip. Agri. (UPM), B.S (Iowa State Univ., USA),
M.S (Louisiana State univ., USA, PhD (Univ. of York, UK)

11 NOVEMBER 2011

Dewan Pertanian
Fakulti Pertanian
Universiti Putra Malaysia

Universiti Putra Malaysia Press
Serdang • 2011
http://www.penerbit.upm.edu.my

First Print 2011

UPM Press is a member of the Malaysian Book Publishers Association (MABOPA)
Membership No.: 9802

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Mohd Fauzi Ramlan
Climate change : crop performance and potentials / Mohd Fauzi Ramlan
Bibliography : p. 29
ISBN 978-967-344-260-7
1.Agricultural ecology. 2. Climate changes 3. Agriculture--
Environmental aspects. 4. Speeches, addresses, etc. I. Title
577.5522

Reka letak teks : Sahariah Abdol Rahim @ Ibrahim
Reka bentuk kulit : Khairul Amin B. Zainal Abidin

Design, layout and printed by
Penerbit Universiti Putra Malaysia
43400 UPM Serdang
Selangor Darul Ehsan
Tel: 03-8946 8855 / 8854
Fax: 03-8941 6172
http://www.penerbit.upm.edu.my

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_2 level that comes together with the higher temperature would certainly affect the crop performances. Since many of the crops are categorised under C_3 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_2 emission in the world. Efforts to bring the CO_2 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_2 emission after 2015. Opening of many new areas for agricultural purposes has contributed to the increase of CO_2 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_2 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.

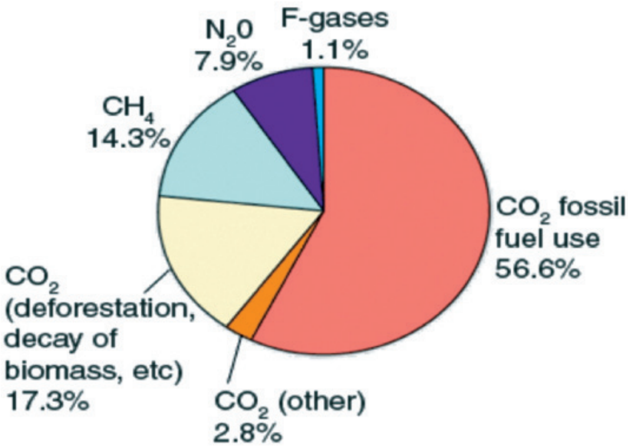


Figure 1 Global greenhouse gas emission (source: 4th Assesment Report: Climate Change 2007: Synthesis Report)

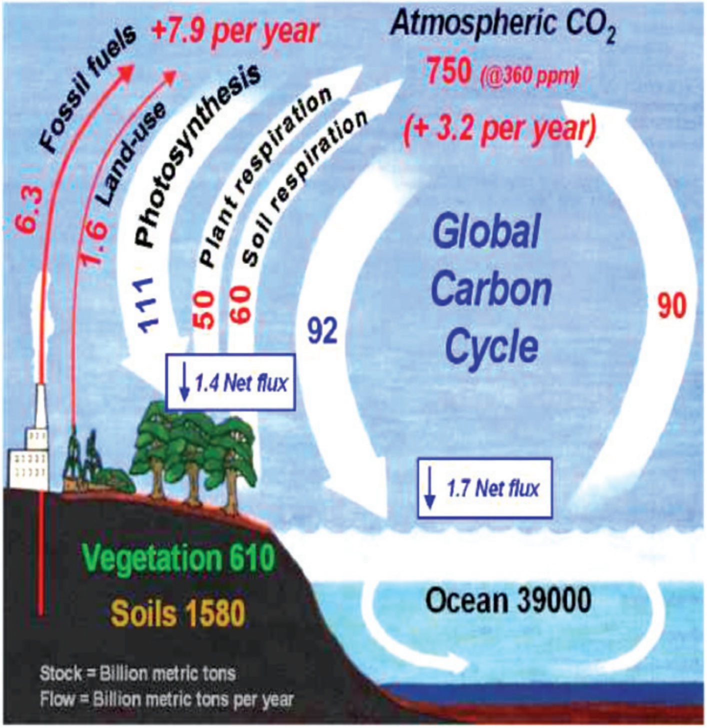


Figure 2 An over view of carbon cycle

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

Figure 2 shows a more in depth cycle of CO_2 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_2 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.

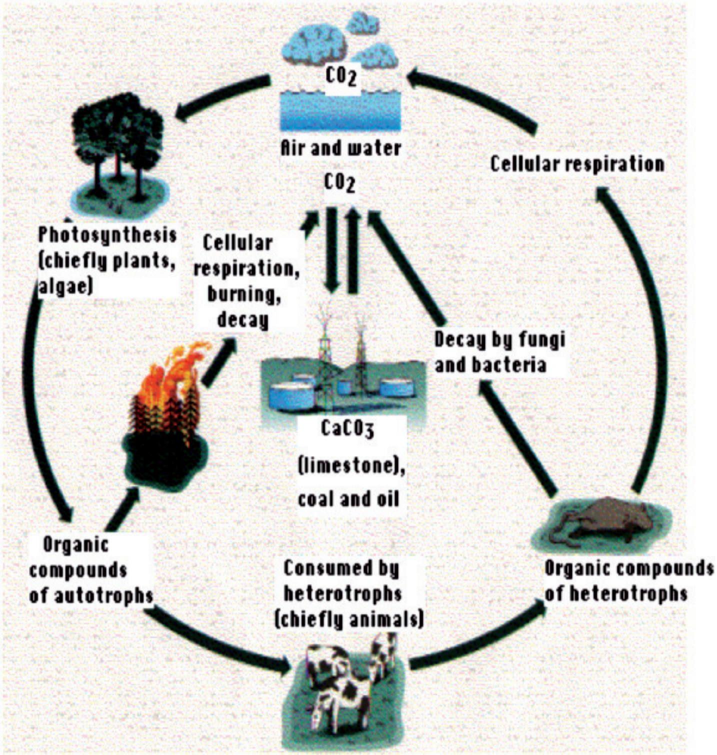


Figure 3 A simplified carbon cycle

Plant physiology has always being 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_2 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).

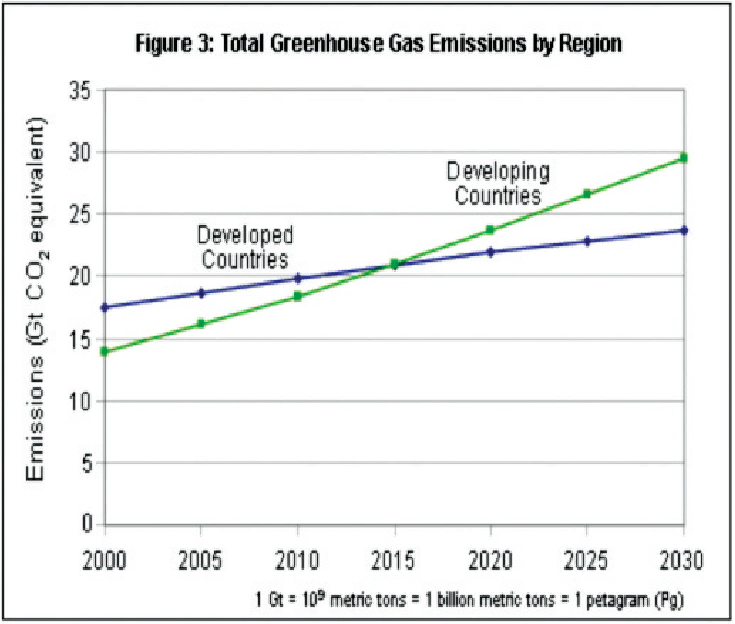


Figure 4 Projection of future greenhouse gas emissions of developed and developing countries

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, un-controlled 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.

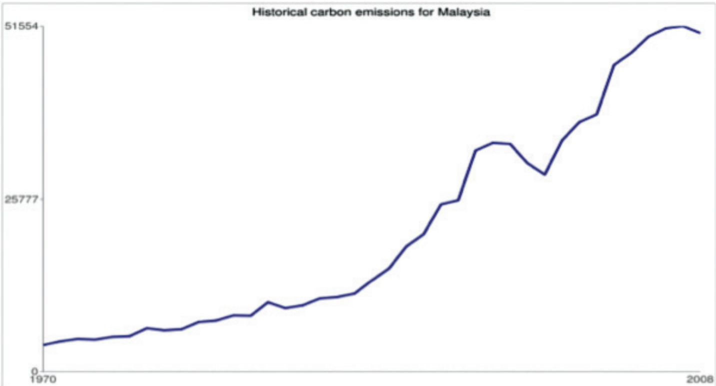


Figure 5 Historical carbon emission for Malaysia (CDIAC)

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 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_2 (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 is 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 concretive 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_2 emission by the countries as reported by APOC

Rank	Country	Annual CO_2 emissions (Metric tones)	Percentage
	World	29,888,121	100%
1.	China[10]	7,031,916	23.33%
2.	United States	5,461,014	18.11%
3.	India	1,742,698	5.78%
4.	Russia	1,708,653	5.67%
5.	Japan	1,208,163	4.01%
6.	Germany	786,660	2.61%
7.	Canada	544,091	1.80%
8.	Iran	538,404	1.79%
9.	United Kingdom	522,856	1.73%
10.	South Korea	509,170	1.69%
15.	Indonesia	406,029	1.35%
22.	Thailand	285,733	0.95%
73.	Singapore	32,295	0.11%
27.	Malaysia	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 CO_2 to 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_3 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/m2/s)	References
Oil palm	20 -24	Corley & Tinker (2003)
Durian	6-14	Ramlan *et al* (1996)
Mangosteen	3	Ramlan *et al* (1992); (Adiwirman *et al*, 2001)
Hopea odorata	8-11	Ahmad Azaruddin (2007)
Acacia mangium	10-14	Sapari Mat (2008)
Syzygium campanulatum	2-4	Ahmad Nazaruddin (2006)

Even though that the perennial fruit trees may not have a high capacity to fix CO_2, 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_2 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.

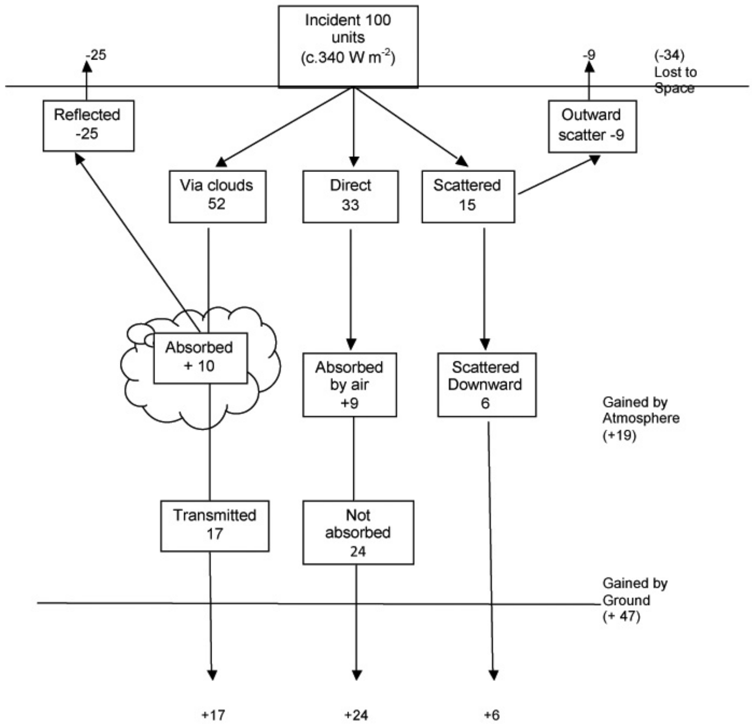


Figure 7 The passage of solar radiation through the atmosphere scattered before reaching to the earth surface

(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_2, most of the C_3 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_2, 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_2 concentration.

Figure 8 shows a normal pattern for relative rates of C_3 and C_4 as influenced by temperature and light intensity. Principally, the C_4 plants are physiologically active with higher photosynthesis activities for hot dry and high light conditions. Moreover photorespiration does not occur in C_4 plants. Therefore, C_4 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_3 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.

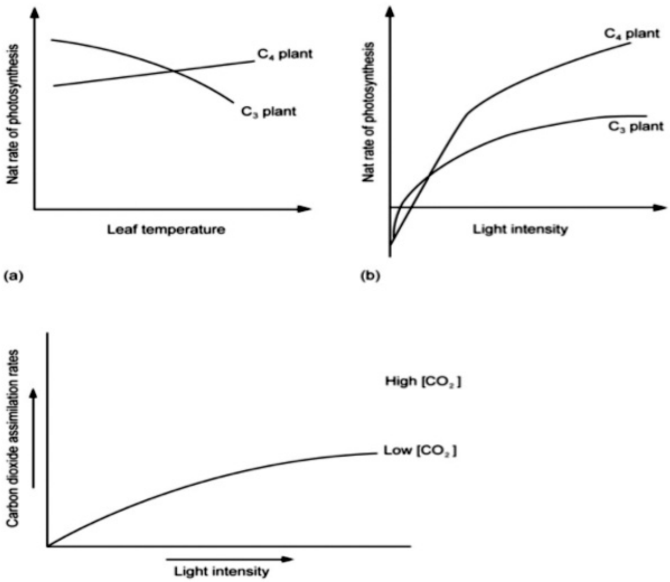


Figure 8 A normal pattern for temperature and light response curve for C_3 and C_4 plants.

However, normal greenhouse simulation indicates that increase of CO_2 alone does not represent the true picture. Increase in CO_2 is followed by the increase in atmospheric temperature. It has been clearly demonstrated that in many C_3 plants the increase in temperature would reduce the photosynthetic capacity of C_3 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_2. 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^{o}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^{o}C to 40^{o}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_4 traits that may increase the photosynthetic ability (Zhu et al., 2010). The C_4 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

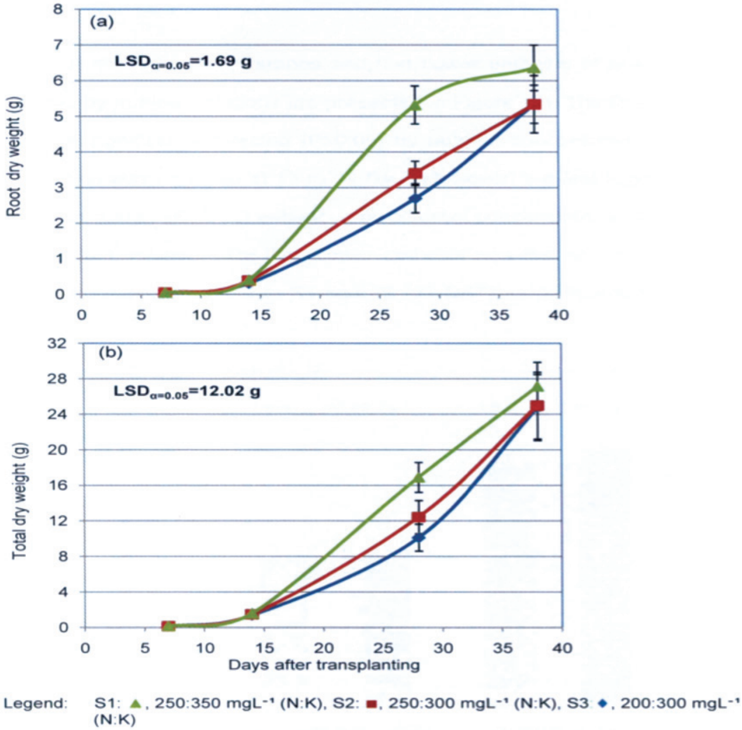
Monitoring the distribution of growth pattern over time would indicate the significant stage for vegetative, reproductive and maturity and senescence. For example, a typical growth of bell pepper plant indicated there is a distinct change in terms of dry weight distribution over vegetative, reproduction 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

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

As indicated by Acquaah (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.



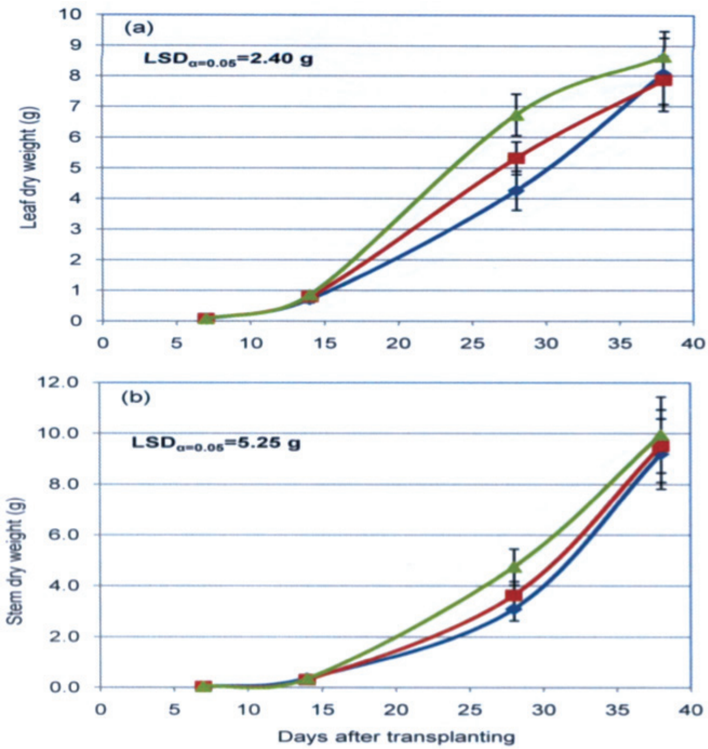


Figure 9 Plant partitioning of bell pepper plantsduring vegetative growth stage grown under different nutritional concentration level

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

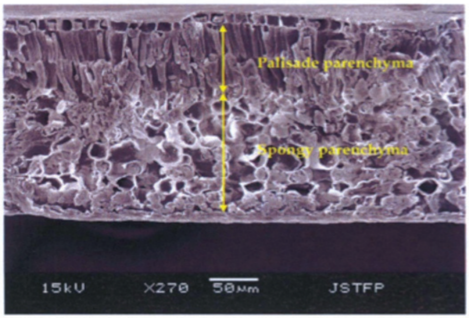
As the awareness for beautification and landscape is on the increase, the knowledge of global and climatic change has also received an overwhelming support from the government and the public. Of late, the uses of native forest species for landscape plants are on the increase. In many of the housing areas 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_2 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

Bamboo species	Relative growth rate (cm/cm/day)
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 at, 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 biofetiliser 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 warning 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_2 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 *Azospirillium* inoculation on N2 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

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 CO2 emission from fossil-fuel burning, cement manufacture and gas flaring: 1751-2006. Carbon DioxideAnlaysisCenter, 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 *Trifoliumsubterraneum* 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. Inaunugral lecture series. UPM.

Mon, K.L., and Chang, C.M. (2008). The impact of drought and flood on paddy cultivation in Muda Irrigation Scheme. 13th Conferenec on Irrigation and Drainage (13th 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 leadered 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 15th, 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 assistsed 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 n 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 Acheh, 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.

ACKNOWLEDGEMENT

Professor Dr. Mohd Fauzi Ramlan would like to acknowledge Universiti Putra Malaysia, Ministry of Agriculture and Agro-based Industry, Ministry of Higher Education, Department of Civil Services and TNB Research and Development for the support financially and opportunities in carring out various studies and bringing him to outmost challenges. He is also thankful to his parents and families for the endless support throughout his career. To his friends and colleges, students and supporting staff, and the university community, he would like to express his sincere gratitude for the unending guidance.

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
   The Challenge to Communication Research in Extension
   22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
   Indigenous Materials and Technology for Low Cost Housing
   30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
   Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
   30 January 1993

4. Prof. Dr. Mohamed Suleiman
   Numerical Solution of Ordinary Differential Equations: A Historical Perspective
   11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
   Changing Roles of Agricultural Economics
   5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
   Marketing Management: Prospects and Challenges for Agriculture
   6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
   The Changing Demand for Livestock Products
   20 April 1994

8. Prof. Dr. Ruth Kiew
   Plant Taxonomy, Biodiversity and Conservation
   11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
   Engineering Technological Developments Propelling Agriculture into the 21st Century
   28 May 1994

10. Prof. Dr. Shamsuddin Jusop
    Rock, Mineral and Soil
    18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
    Natural Toxicants Affecting Animal Health and Production
    29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
    Pest Control: A Challenge in Applied Ecology
    9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
    Managing Challenges in Fisheries Development through Science and Technology
    23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
    Sejarah Keagungan Bahasa Melayu
    6 Ogos 1994

15. Prof. Dr. Law Ah Theem
    Oil Pollution in the Malaysian Seas
    24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
    Fine Chemicals from Biological Resources: The Wealth from Nature
    21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
    Health, Disease and Death in Creatures Great and Small
    25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
    Fish Health: An Odyssey through the Asia - Pacific Region
    25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
    Chromosome Distribution and Production Performance of Water Buffaloes
    6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
    Bahasa Melayu sebagai Bahasa Ilmu- Cabaran dan Harapan
    10 Jun 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
22 March 1997

40. Prof. Dr. Suhaila Mohamad
    Food and Its Healing Power
    12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
    A Distributed Collaborative Environment for Distance Learning Applications
    17 June 1998

42. Prof. Dr. Wong Kai Choo
    Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
    15 May 1999

43. Prof. Dr. Aini Ideris
    Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
    10 July 1999

44. Prof. Dr. Sariah Meon
    Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
    14 August 1999

45. Prof. Dr. Azizah Hashim
    The Endomycorrhiza: A Futile Investment?
    23 Oktober 1999

46. Prof. Dr. Noraini Abdul Samad
    Molecular Plant Virology: The Way Forward
    2 February 2000

47. Prof. Dr. Muhamad Awang
    Do We Have Enough Clean Air to Breathe?
    7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
    Green Environment, Clean Power
    24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
    Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
    12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 Januari 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
28 February 2002

52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
13 April 2002

54. Prof. Dr. Maisom Abdullah
Productivity Driven Growth: Problems & Possibilities
27 April 2002

55. Prof. Dr. Wan Omar Abdullah
Immunodiagnosis and Vaccination for Brugian Filariasis: Direct Rewards from Research Investments
6 June 2002

56. Prof. Dr. Syed Tajuddin Syed Hassan
Agro-ento Bioinformation: Towards the Edge of Reality
22 June 2002

57. Prof. Dr. Dahlan Ismail
Sustainability of Tropical Animal-Agricultural Production Systems: Integration of Dynamic Complex Systems
27 June 2002

58. Prof. Dr. Ahmad Zubaidi Baharumshah
The Economics of Exchange Rates in the East Asian Countries
26 October 2002

59. Prof. Dr. Shaik Md. Noor Alam S.M. Hussain
Contractual Justice in Asean: A Comparative View of Coercion
31 October 2002

60. Prof. Dr. Wan Md. Zin Wan Yunus
Chemical Modification of Polymers: Current and Future Routes for Synthesizing New Polymeric Compounds
9 November 2002

61. Prof. Dr. Annuar Md. Nassir
Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
21 February 2003

63. Prof. Dr. Shamsher Mohamad
The New Shares Market: Regulatory Intervention, Forecast Errors and Challenges
26 April 2003

64. Prof. Dr. Han Chun Kwong
Blueprint for Transformation or Business as Usual? A Structurational Perspective of the Knowledge-Based Economy in Malaysia
31 May 2003

65. Prof. Dr. Mawardi Rahmani
Chemical Diversity of Malaysian Flora: Potential Source of Rich Therapeutic Chemicals
26 July 2003

66. Prof. Dr. Fatimah Md. Yusoff
An Ecological Approach: A Viable Option for Aquaculture Industry in Malaysia
9 August 2003

67. Prof. Dr. Mohamed Ali Rajion
The Essential Fatty Acids-Revisited
23 August 2003

68. Prof. Dr. Azhar Md. Zain
Psychotheraphy for Rural Malays - Does it Work?
13 September 2003

69. Prof. Dr. Mohd. Zamri Saad
Respiratory Tract Infection: Establishment and Control
27 September 2003

70. Prof. Dr. Jinap Selamat
Cocoa-Wonders for Chocolate Lovers
14 February 2004

71. Prof. Dr. Abdul Halim Shaari
High Temperature Superconductivity: Puzzle & Promises
13 March 2004

72. Prof. Dr. Yaakob Che Man
Oils and Fats Analysis - Recent Advances and Future Prospects
27 March 2004

73. Prof. Dr. Kaida Khalid
Microwave Aquametry: A Growing Technology
24 April 2004

74. Prof. Dr. Hasanah Mohd. Ghazali
Tapping the Power of Enzymes- Greening the Food Industry
11 May 2004

75. Prof. Dr. Yusof Ibrahim
The Spider Mite Saga: Quest for Biorational Management Strategies
22 May 2004

76. Prof. Datin Dr. Sharifah Md. Nor
The Education of At-Risk Children: The Challenges Ahead
26 June 2004

77. Prof. Dr. Ir. Wan Ishak Wan Ismail
Agricultural Robot: A New Technology Development for Agro-Based Industry
14 August 2004

78. Prof. Dr. Ahmad Said Sajap
Insect Diseases: Resources for Biopesticide Development
28 August 2004

79. Prof. Dr. Aminah Ahmad
The Interface of Work and Family Roles: A Quest for Balanced Lives
11 March 2005

80. Prof. Dr. Abdul Razak Alimon
Challenges in Feeding Livestock: From Wastes to Feed
23 April 2005

81. Prof. Dr. Haji Azimi Hj. Hamzah
Helping Malaysian Youth Move Forward: Unleashing the Prime Enablers
29 April 2005

82. Prof. Dr. Rasedee Abdullah
In Search of An Early Indicator of Kidney Disease
27 May 2005

83. Prof. Dr. Zulkifli Hj. Shamsuddin
Smart Partnership: Plant-Rhizobacteria Associations
17 June 2005

84. Prof. Dr. Mohd Khanif Yusop
From the Soil to the Table
1 July 2005

85. Prof. Dr. Annuar Kassim
Materials Science and Technology: Past, Present and the Future
8 July 2005

86. Prof. Dr. Othman Mohamed
Enhancing Career Development Counselling and the Beauty of Career Games
12 August 2005

87. Prof. Ir. Dr. Mohd Amin Mohd Soom
Engineering Agricultural Water Management Towards Precision Framing
26 August 2005

88. Prof. Dr. Mohd Arif Syed
Bioremediation-A Hope Yet for the Environment?
9 September 2005

89. Prof. Dr. Abdul Hamid Abdul Rashid
The Wonder of Our Neuromotor System and the Technological Challenges They Pose
23 December 2005

90. Prof. Dr. Norhani Abdullah
Rumen Microbes and Some of Their Biotechnological Applications
27 January 2006

91. Prof. Dr. Abdul Aziz Saharee
Haemorrhagic Septicaemia in Cattle and Buffaloes: Are We Ready for Freedom?
24 February 2006

92. Prof. Dr. Kamariah Abu Bakar
Activating Teachers' Knowledge and Lifelong Journey in Their Professional Development
3 March 2006

93. Prof. Dr. Borhanuddin Mohd. Ali
Internet Unwired
24 March 2006

94. Prof. Dr. Sundararajan Thilagar
Development and Innovation in the Fracture Management of Animals
31 March 2006

95. Prof. Dr. Zainal Aznam Md. Jelan
Strategic Feeding for a Sustainable Ruminant Farming
19 May 2006

96. Prof. Dr. Mahiran Basri
Green Organic Chemistry: Enzyme at Work
14 July 2006

97. Prof. Dr. Malik Hj. Abu Hassan
Towards Large Scale Unconstrained Optimization
20 April 2007

98. Prof. Dr. Khalid Abdul Rahim
Trade and Sustainable Development: Lessons from Malaysia's Experience
22 Jun 2007

99. Prof. Dr. Mad Nasir Shamsudin
Econometric Modelling for Agricultural Policy Analysis and Forecasting: Between Theory and Reality
13 July 2007

100. Prof. Dr. Zainal Abidin Mohamed
Managing Change - The Fads and The Realities: A Look at Process Reengineering, Knowledge Management and Blue Ocean Strategy
9 November 2007

101. Prof. Ir. Dr. Mohamed Daud
Expert Systems for Environmental Impacts and Ecotourism Assessments
23 November 2007

102. Prof. Dr. Saleha Abdul Aziz
Pathogens and Residues; How Safe is Our Meat?
30 November 2007

103. Prof. Dr. Jayum A. Jawan
Hubungan Sesama Manusia
7 Disember 2007

104. Prof. Dr. Zakariah Abdul Rashid
Planning for Equal Income Distribution in Malaysia: A General Equilibrium Approach
28 December 2007

105. Prof. Datin Paduka Dr. Khatijah Yusoff
Newcastle Disease virus: A Journey from Poultry to Cancer
11 January 2008

106. Prof. Dr. Dzulkefly Kuang Abdullah
Palm Oil: Still the Best Choice
1 February 2008

107. Prof. Dr. Elias Saion
Probing the Microscopic Worlds by Lonizing Radiation
22 February 2008

108. Prof. Dr. Mohd Ali Hassan
Waste-to-Wealth Through Biotechnology: For Profit, People and Planet
28 March 2008

109. Prof. Dr. Mohd Maarof H. A. Moksin
Metrology at Nanoscale: Thermal Wave Probe Made It Simple
11 April 2008

110. Prof. Dr. Dzolkhifli Omar
The Future of Pesticides Technology in Agriculture: Maximum Target Kill with Minimum Collateral Damage
25 April 2008

111. Prof. Dr. Mohd. Yazid Abd. Manap
Probiotics: Your Friendly Gut Bacteria
9 May 2008

112. Prof. Dr. Hamami Sahri
Sustainable Supply of Wood and Fibre: Does Malaysia have Enough?
23 May 2008

113. Prof. Dato' Dr. Makhdzir Mardan
Connecting the Bee Dots
20 June 2008

114. Prof. Dr. Maimunah Ismail
Gender & Career: Realities and Challenges
25 July 2008

115. Prof. Dr. Nor Aripin Shamaan
Biochemistry of Xenobiotics: Towards a Healthy Lifestyle and Safe Environment
1 August 2008

116. Prof. Dr. Mohd Yunus Abdullah
Penjagaan Kesihatan Primer di Malaysia: Cabaran Prospek dan Implikasi dalam Latihan dan Penyelidikan Perubatan serta Sains Kesihatan di Universiti Putra Malaysia
8 Ogos 2008

117. Prof. Dr. Musa Abu Hassan
Memanfaatkan Teknologi Maklumat & Komunikasi ICT untuk Semua
15 Ogos 2008

118. Prof. Dr. Md. Salleh Hj. Hassan
Role of Media in Development: Strategies, Issues & Challenges
22 August 2008

119. Prof. Dr. Jariah Masud
Gender in Everyday Life
10 October 2008

120 Prof. Dr. Mohd Shahwahid Haji Othman
Mainstreaming Environment: Incorporating Economic Valuation and Market-Based Instruments in Decision Making
24 October 2008

121. Prof. Dr. Son Radu
Big Questions Small Worlds: Following Diverse Vistas
31 Oktober 2008

122. Prof. Dr. Russly Abdul Rahman
Responding to Changing Lifestyles: Engineering the Convenience Foods
28 November 2008

123. Prof. Dr. Mustafa Kamal Mohd Shariff
Aesthetics in the Environment an Exploration of Environmental: Perception Through Landscape Preference
9 January 2009

124. Prof. Dr. Abu Daud Silong
Leadership Theories, Research & Practices: Farming Future Leadership Thinking
16 January 2009

125. Prof. Dr. Azni Idris
Waste Management, What is the Choice: Land Disposal or Biofuel?
23 January 2009

126. Prof. Dr. Jamilah Bakar
Freshwater Fish: The Overlooked Alternative
30 January 2009

127. Prof. Dr. Mohd. Zobir Hussein
The Chemistry of Nanomaterial and Nanobiomaterial
6 February 2009

128. Prof. Ir. Dr. Lee Teang Shui
Engineering Agricultural: Water Resources
20 February 2009

129. Prof. Dr. Ghizan Saleh
Crop Breeding: Exploiting Genes for Food and Feed
6 March 2009

130. Prof. Dr. Muzafar Shah Habibullah
Money Demand
27 March 2009

131. Prof. Dr. Karen Anne Crouse
In Search of Small Active Molecules
3 April 2009

132. Prof. Dr. Turiman Suandi
Volunteerism: Expanding the Frontiers of Youth Development
17 April 2009

133. Prof. Dr. Arbakariya Ariff
Industrializing Biotechnology: Roles of Fermentation and Bioprocess Technology
8 Mei 2009

134. Prof. Ir. Dr. Desa Ahmad
Mechanics of Tillage Implements
12 Jun 2009

135. Prof. Dr. W. Mahmood Mat Yunus
Photothermal and Photoacoustic: From Basic Research to Industrial Applications
10 Julai 2009

136. Prof. Dr. Taufiq Yap Yun Hin
Catalysis for a Sustainable World
7 August 2009

137 Prof. Dr. Raja Noor Zaliha Raja Abd. Rahman
Microbial Enzymes: From Earth to Space
9 Oktober 2009

138 Prof. Ir. Dr. Barkawi Sahari
Materials, Energy and CNGDI Vehicle Engineering
6 November 2009

139. Prof. Dr. Zulkifli Idrus
Poultry Welfare in Modern Agriculture: Opportunity or Threat?
13 November 2009

140. Prof. Dr. Mohamed Hanafi Musa
Managing Phosphorus: Under Acid Soils Environment
8 January 2010

141. Prof. Dr. Abdul Manan Mat Jais
Haruan Channa striatus a Drug Discovery in an Agro-Industry Setting
12 March 2010

142. Prof. Dr. Bujang bin Kim Huat
Problematic Soils: In Search for Solution
19 March 2010

143. Prof. Dr. Samsinar Md Sidin
Family Purchase Decision Making: Current Issues & Future Challenges
16 April 2010

144. Prof. Dr. Mohd Adzir Mahdi
Lightspeed: Catch Me If You Can
4 June 2010

145. Prof. Dr. Raha Hj. Abdul Rahim
Designer Genes: Fashioning Mission Purposed Microbes
18 June 2010

146. Prof. Dr. Hj. Hamidon Hj. Basri
A Stroke of Hope, A New Beginning
2 July 2010

147. Prof. Dr. Hj. Kamaruzaman Jusoff
Going Hyperspectral: The "Unseen" Captured?
16 July 2010

148. Prof. Dr. Mohd Sapuan Salit
Concurrent Engineering for Composites
30 July 2010

149. Prof. Dr. Shattri Mansor
Google the Earth: What's Next?
15 October 2010

150. Prof. Dr. Mohd Basyaruddin Abdul Rahman
Haute Couture: Molecules & Biocatalysts
29 October 2010

151. Prof. Dr. Mohd. Hair Bejo
Poultry Vaccines: An Innovation for Food Safety and Security
12 November 2010

152. Prof. Dr. Umi Kalsom Yusuf
Fern of Malaysian Rain Forest
3 December 2010

153. Prof. Dr. Ab. Rahim Bakar
Preparing Malaysian Youths for The World of Work: Roles of Technical and Vocational Education and Training (TVET)
14 January 2011

154. Prof. Dr. Seow Heng Fong
Are there "Magic Bullets" for Cancer Therapy?
11 February 2011

155. Prof. Dr. Mohd Azmi Mohd Lila
Biopharmaceuticals: Protection, Cure and the Real Winner
18 February 2011

156. Prof. Dr. Siti Shapor Siraj
Genetic Manipulation in Farmed Fish: Enhancing Aquaculture Production
25 March 2011

157. Prof. Dr. Ahmad Ismail
Coastal Biodiversity and Pollution: A Continuous Conflict
22 April 2011

158. Prof. Ir. Dr. Norman Mariun
Energy Crisis 2050? Global Scenario and Way Forward for Malaysia
10 June 2011

159. Prof. Dr. Mohd Razi Ismail
Managing Plant Under Stress: A Challenge for Food Security
15 July 2011

160. Prof. Dr. Patimah Ismail
Does Genetic Polymorphisms Affect Health?
23 September 2011

161. Prof. Dr. Sidek Ab. Aziz
Wonders of Glass: Synthesis, Elasticity and Application
7 October 2011

162. Prof. Dr. Azizah Osman
Fruits: Nutritious, Colourful, Yet Fragile Gifts of Nature
14 October 2011