

## APPLYING SEASONAL CLIMATE TRENDS TO AGRICULTURAL PRODUCTION IN TANJUNG KARANG, MALAYSIA

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### ABSTRACT

The North West Selangor Integrated Agriculture Development Agency (NWS-IADA) is the most productive agricultural part in Selangor, Malaysia. This is partly because of the inherent high fertility of the soils and the moderate variable climate. However, with increasing global concern about climate impacts, this article examines relative importance of climate influences on the paddy production rate over 28 years (1980-2008). Data collection involved compiling and analyzing climate records from auxiliary station MARDI, Tg. Karang, Malaysia (Station no. 44325, 24 m M.S.L) at the coordinates of N 03° 27' 17" E 101° 09' 24". The results indicate that the average rainfall recorded is 1,765 mm which is similar to national rainfall trend. Meanwhile, the daily humidity varied between 94-96% (8.00 AM) and around 70% (2.00 PM) while the sunshine hours ranged between 2.3 to 9.5 h. A correlation analysis between the production yield and climatic data at the studied area for the year 2000-2008, showed that for precipitation; rainfall is redundant during the main season while during the off season it bears direct effect on the production yield with the R<sup>2</sup> value of -0.293 and 0.1715, respectively; Sunshine hours and temperature demonstrate their importance to production yield as suggested with their respective R<sup>2</sup> values.

**Keywords:** Weather Trend, Paddy Planting, Climate Trend, Agriculture, Irrigation

### 1. INTRODUCTION

Paddy planting in Malaysia is synonymous to the rural community and traditional farming. The Government of Malaysia have initiated measures to assist the local paddy producing community through the introduction of incentives such as declaring the rice crop to be a security crop, the launching of the National Agriculture Act (1992-2010), the upgrading of existing irrigation systems and the building of new irrigation systems, the market price control and other measures to further boost the local production (Alam *et al.*, 2011).

The local paddy producing community is self-sustainable to 86% of local market demand while the remaining unfulfilled market demand is mitigated by importing rice from the neighboring rice producing countries such as Thailand, Indonesia, India and Cambodia. Increasing crop yield is the main agenda of most local paddy growers through measures such as the introduction of new cultivars, reviewing existing planting practices such as fertilizing and pesticide cycle, type and amount of fertilizer and pesticide used and the intensity and frequency of such cycle.

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Traditionally, Malaysia is a rice-growing country with irrigation system has gone through evolution over the past decades with new ideas were implemented and new technologies were introduced. Government, through their agencies such as Drainage and Irrigation Malaysia (DID), Muda Agricultural Development Authority (MADA) and Kemubu Agriculture Development Authority (KADA) play a vital role to improve irrigation system throughout the region. From traditional irrigation system which enable farmers to plant once a year, farmers currently could implement double and triple cropping of rice a year since 1988 and 1999, respectively. Although in the 1980s, there was a substantial reduction in rainfall and overall availability of water resources for irrigation in the region, farmers still were able to increase total crop output by about 16% over the decade (Peng *et al.*, 2006).

However, with uncertainties on economic production and climate variability, producing more rice had become a continuous challenge among the government and paddy farmers (Siwar *et al.*, 2009). This includes the efficient utilization of water resources, good management practices and precise information, such as annual effective rainfall, runoff, consumptive use and water release policy. In this regards, an ideal water management can be achieved through the delivery of the right amount of irrigation water at the right time to the fields to increase crop yield.

Paddy planting has been long documented as the main economic activity of the rural community in Malaysia, with an average planting area of 651,600 ha for the combination of main and off season in the years of 1900's (ICDC, 2002). Yet, there is a steady annual decline in terms of planting area. In terms of land use, the paddy plant is the third most important crop in Malaysia; after the oil palm plant (2.3 million ha) and the rubber plant (1.8 million ha) (ICDC, 2002).

Malaysia is a small rice producing country in the global market with a rice production output only 0.4% of the global rice output. Most paddy growers in Malaysia are small scaled with an average planting area of 1.06 ha despite reporting 286,000 paddy growers in Malaysia where 116,000 of them are full time paddy growers with no fall back and solely rely on the outcome of their paddy production as an income source (Alam *et al.*, 2010). A total of 65% of these farmers

have planted area smaller than 1 ha while only 3% of the paddy growers were planting area of more than 3 ha (Latif, 1991). The sensitivity of the paddy crop towards the environment which directly impacts its production rate makes the factors governing its environment very crucial in the efforts to increase the production rate of the local granaries. These factors include a variety of aspects such as its fertilizing cycle, soil physical-chemical properties, plant cultivate, pesticide and weather trend (Toriman *et al.*, 2009).

Among all the contributing factors, the climate trend is a factor that is beyond the control and could only be mitigated after certain events. The ability to have an insight into the weather trend would greatly assist the local paddy growing community in terms of managing the effect of the weather in terms of affecting the growth cycle of the paddy plant and in turn increase the production rate.

Focusing the general adaptation for irrigation for paddy in Malaysia, this article discusses the impacts of climate change in Peninsular Malaysia, particularly to irrigate such one big scheme especially when shortage of water occurs. Finally this article also deals the key to saving water and achieving high efficiency through proper irrigation management and distribution of water.

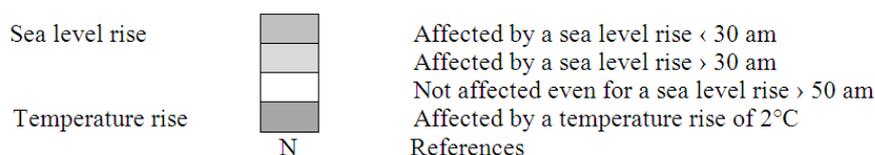
This article analysis a climate- time series data over 28 years commencing 1980 to 2008 at North West Selangor Integrated Agriculture Development Agency (NWS-IADA), Tg. Karang, Selangor, Malaysia.

### 1.1. Climate Change Scenario

Scientific assessment indicates that the coastline of Southeast Asia including Malaysia are highly vulnerable to the effects of climate change (Belinda and Leon, 2009). In reality, climate change challenge is real and urgent in Southeast Asia. Global climate change scenarios predict that the region's annual temperature will increase in the order of 0.4-1.3°C by 2030 and 0.9-4.0 deg C by 2070 while winter rainfall is projected to decrease (less than 10% by 2030 and approximately 20-30% by 2070). The effect of a rise in global sea level on the region may be as much as 3-16 cm by 2030 and 7-50 cm by 2070 (ICDC, 2002). **Figure 1** shows the impacts of sea level and temperature rises for Malaysia and other South East Asia Countries.

Climate change impact	Sea level rise(m)	Temperature rise (°C)
Brunei		
Cambodia		7
Indonesia 3 8	3	8,9
Lao PDR 7		7
Malaysia 5	5	
Myanmar 7		7
Philippines		10
Singapore		
Thailand		7,11
Timor-Leste		9
Vietnam	1,4,6	7

Caption:



(Source: Belinda and Leon, 2009)

**Fig. 1.** Estimated impact of climate change to Southeast Asia

The global aggregate effect of climate change on paddy production is likely to be small to moderate. However, regional impacts could be significant. Paddy yields and changes in productivity will vary considerably across regions. These regional variations in gains and losses will probably result in a slight overall decrease in world cereal grain productivity (Siwar *et al.*, 2009). The effect of the temperature on paddy mainly governs the timing of physiological process, the rate of expansion and survival reproductive structures. Increases in temperature affect the moisture availability through effects on evaporation; in general evaporation increases by about 5% for each 1°C increase in main annual temperature. This would be significant in tropical regions where most crops, particularly paddy are generally constrained by water availability (NRS, 2001; Al-Amin and Siwar, 2008).

Meanwhile, the impact of climate change on rice production has been subjected to many scientific researches due to its important on human being. The average potential yield of rice varies is about 10 tons ha<sup>-1</sup> in the tropics and over 13 tons ha<sup>-1</sup> in temperate region (Al-Amin and Siwar, 2008). The actual farm yields in Malaysia vary from 3 to 5 tons ha<sup>-1</sup>, (i.e., potential yield in Malaysia per ha<sup>-1</sup> is 7.2 tons (Singh *et al.*, 1996). Based on experimental data obtained elsewhere, the

rice crop, in general responds positively (until certain limit) to an increase in atmospheric CO<sup>2</sup> concentration (Siwar *et al.*, 2009).

The development rates of rice crop were accelerated in response to an increase in CO<sup>2</sup> concentration from 160 ppm (parts per million) to 900 ppm. However the yield response to CO<sup>2</sup> varies with cultivars, location and management practice. It is evident that the average response to an increase of potential yields of about 10kg/ha/ppm CO<sup>2</sup> or about 15kg/ha/ ppm CO<sup>2</sup>. However the negative effects occur in unexpected high or low temperature (Penning, 1993). Temperature affects rice growth in two ways; first, a critically low or high temperature defines the environment under which the life cycle can be completed. Secondly, within the critically low and high temperature range, temperature influences the rate of development of leaves and panicles and the rate of ripening, thereby fixing the duration of growth of a variety under a given environment and eventually determining the suitability of the variety to the environment (Yoshida, 1981). As the world populations is projected to reach 8.4 billion by 2030, of which over 5 billion will live on rice, it is feared that the increasing trend toward global warming and frequent outbreaks of extreme weather will be a serious blow to rice production (Siwar *et al.*, 2009).

## 2. MATERIALS AND METHODS

The study area is located at the North West Selangor Integrated Agriculture Development Agency (NWS-IADA). The scheme was launched on 6th June 1978 and covers approximately an area of 19,920 ha. The paddy planting practices carried out is based on the Bestari Planting Guide proposed by Malaysia Agriculture Research and Development Institute (MARDI) while the main cultivate used in the study area is a local cultivar (MR219). This cultivar is capable in producing high yield. A small amount of paddy growers also uses other local cultivars for planting (Toriman *et al.*, 2009). The broadcasting technique is mainly used by the paddy growers while those who could afford it would practice the transplanting technique through the help of a rented mechanical transplanted.

The data for this study is gathered from the Malaysia Meteorological Department and the observed result for the studied area including parameters of mean daily, temperature, daily humidity, rain distribution and daily sunshine hours for the auxiliary station in MARDI Tg. Karang (Station no. 44325) at the coordinates of N 03° 27' 17" E 101° 09' 24" with 2.4m at mean sea level. The location of the weather station which is surrounded by paddy field and is strategically located amidst the North West Selangor Integrated Agriculture Development Agency (NWS-IADA) planting area would correctly reflect the nature of the weather trend at this granary.

## 3. RESULTS

### 3.1. Temperature

The study showed that the study area displayed a constant annual temperature trend with an average in the range of 23°C to 32°C;  $R^2$  value of 0.246 and 0.0139 respectively. The data shows that it still complies within the daily mean temperature of Malaysia (Siwar *et al.*, 2009) (Fig. 2). The temperature variation recorded throughout the years is due to the influence of the monsoons where the studied area generally recorded higher temperature during the months of March until June annually which coincide as the off season for the study area.

The temperature recorded shows that the trend is constant in the studied area. This is evident in the paddy plant's growth as temperature fluctuations incur dire

effects to the paddy plant such as retard development in seedlings, delayed transplanting and reduced tiller formation during the early stages of growth; it could even lead to plant sterility if temperature stress were induced before antacids date (Grist, 1983; Sharfi and Hashem, 2010). Though this effect could be remedied if sufficient irrigation is supplied extremities in temperature would still affect the growth cycle of the granary area.

### 3.2. Rainfall Distribution

The study area generally displayed a higher rain distribution during the beginning and the end of a year with an average range of 1, 765 mm (Fig. 3) and  $R^2$  value of 0.0048. The frequency of precipitation is higher at the specific period of October to February; concurring with the scheduled Main Season of the study area. While during the off season, rain distribution is rather low in comparison to the rain distribution recorded in the country as a whole.

Planting during the off season relies heavily to the existing local irrigation scheme in terms of sustaining the paddy planting where the crops could not be subjected to unfavorable conditions such as water stress to minimise the probability of facing total crop lost. Water stress inflicted upon a maturing crop has been known to have dismal effect such as disruption of nutrient intake, delayed flowering and poor grain filling (Grist, 1983; Shi *et al.*, 2002). The rain distribution clearly shows a stable and coherent trend which suggest that the climate trend is still suitable to the granary area of NWS-IADA, Tg Karang, Selangor, Malaysia.

### 3.3. Daily Humidity

The percentage of mean daily humidity recorded at the studied area falls in the range of 94-96% (8.00 AM) with  $R^2$  value of 0.121 and around 70% (2.00 PM) for the years of 1983-2008 (Fig. 4). A high percentage of daily humidity is conducive to the optimum growth of the paddy plant and thus affects its yield production, especially true during the off season planting where the area receives insufficient rate of precipitation. Insufficient humidity percentage in the granary area could affect its growth cycle but the ability of the paddy plant to regulate its own microclimate would raise the relative humidity within the crop when sufficient irrigation is supplied (Grist, 1983; Mojtaba *et al.*, 2009; Sharfi and Hashem, 2010).

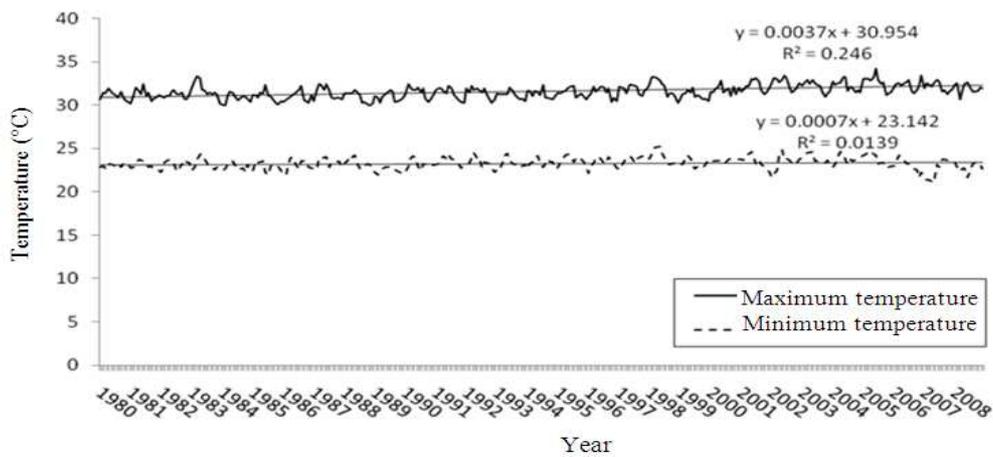


Fig. 2. Daily Maximum and minimum temperature trend at NWS-IADA, Tg. Karang, Selangor, Malaysia

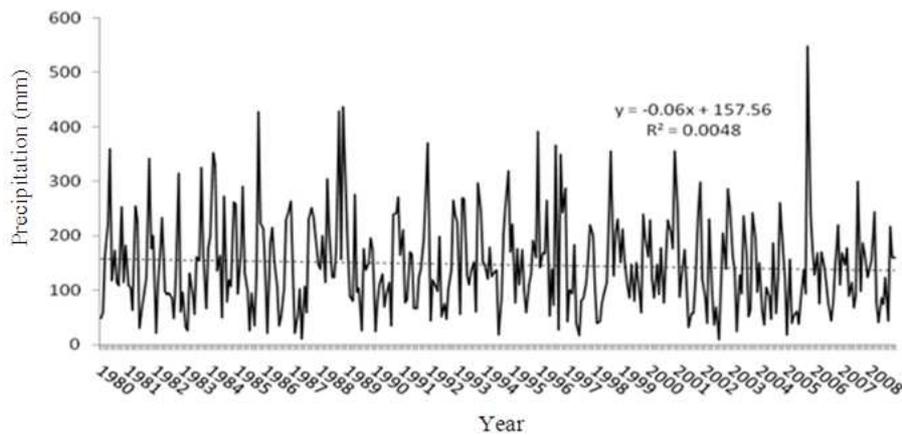


Fig. 3. Rain Distribution (mm) of Monthly Average at PBLs Tg. Karang, Selangor, Malaysia

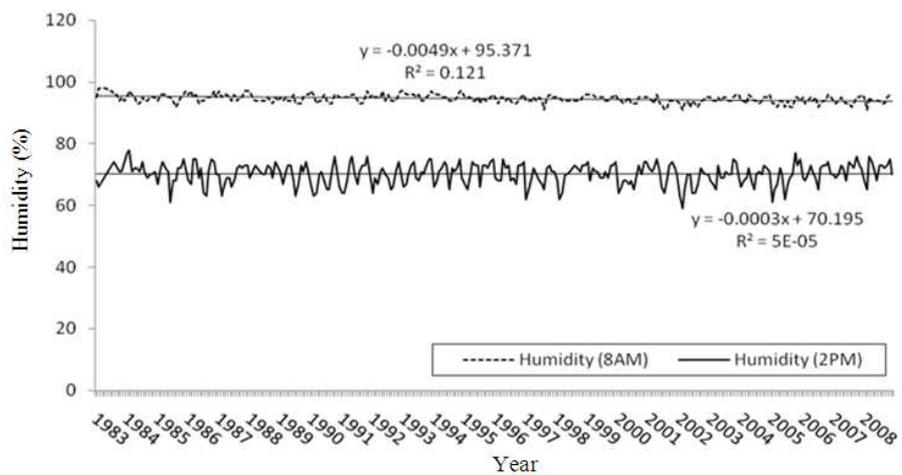


Fig. 4. Daily humidity monthly average at NWS-IADA, Tg. Karang, Selangor, Malaysia

### 3.4. Daily Sunshine Hours

The study area displayed an average daily sunshine hours in the range of 2.3 to 9.5 h and  $R^2$  value of 0.0062; the trend line shows longer sunshine hours during the middle of the year and shorter sunshine hours during the beginning and end of the year just as the nature of the seasonal monsoon in the country.

The data provided by Malaysia Meteorological Department is constricted to the years 1983-2005 but it clearly shows an existing trend for this parameter in the study area of NWS-IADA, Tg. Karang, Selangor, Malaysia (Fig. 5). The importance of sufficient sunlight to the paddy plant can be easily recognized as the number of tillers and ears increases with the intensity and quantity of light (Grist, 1983). As shading has been proven to decrease in number of spikelet per panicle it demonstrates the importance of light to the paddy plant; a high efficiency solar energy conversion plant during the ripening period (Shi *et al.*, 2002).

### 3.5. Climate Trends and Paddy Production

Weather is of an utmost importance in terms of affecting crop production especially true in the case of the paddy plant which has specific needs in each stage of the growth cycle (Grist, 1983; Solomon, 2007;

Ebrahim *et al.*, 2009). In accordance to the publication by Integrated Agriculture Development Agency (IADA, 2009b), a time series data for the year 1999 to 2008 showed an increase in production yield despite an annual report of decrease in planting area (Table 1).

A correlation analysis between the production yield and climatic data available in NWS-IADA, Selangor for the year 2000-2008 showed that for precipitation; rainfall is redundant during the main season while during the off season it bears direct effect on the production yield with the  $R^2$  value of -0.293 and 0.1715 respectively; while, sunshine hours and temperature demonstrates their importance to production yield as suggested with the  $R^2$  values as shown in Table 2 (Grist, 1983; Solomon, 2007). This determines the importance of the local irrigation scheme and stable climate trend to any granary in sustaining a stable and suitable environment for the paddy plant to grow into maturity and produce an economic yield.

Where:

- SUNH = Sunshine hour
- HUM8 = Humidity at 8 am
- HUM2 = Humidity at 2 pm
- TMAX = Maximum temperature
- TMIN = Minimum temperature

**Table 1.** Time series data for the average yield and paddy production of NWS-IADA, granary area, 1999-2008

Year	Planting area (Ha)	Main season		Off season		
		Average paddy yield (Kg/Ha)	Paddy production (Tone Metric)	Planting area (Ha)	Average paddy yield (Kg/Ha)	Paddy production (Tone Metric)
1999	18,669	4,087	76,300	18,691	4,325	80,839
2000	18,637	4,569	85,152	18,521	4,790	88,716
2001	18,613	5,193	96,657	18,619	4,984	92,797
2002	18,607	4,752	88,420	18,607	4,768	88,718
2003	18,565	5,492	101,959	18,583	5,269	97,914
2004	18,604	5,174	96,257	18,629	4,485	81,741
2005	18,292	5,242	95,884	18,226	4,384	79,900
2006	18,399	4,877	89,732	18,355	4,557	83,644
2007	18,340	4,942	90,636	18,176	5,143	93,479
2008	18,301	4,542	83,127	18,301	4,979	91,121

Source: IADA (2009a)

**Table 2.** Correlation analysis of the production rate of NWS-IADA, Granary area and climatic data for the year 1999-2008

	Main season	Off season	Precipitation	SUNH	HUM8	HUM2	TMAX	TMIN
Main season	1.0000							
Off season	0.3362	1.0000						
Precipitation	-0.2930	0.1715	1.0000					
SUNH	0.3061	-0.4290	-0.4230	1.0000				
HUM8	-0.2980	-0.0340	-0.0260	-0.6720	1.0000			
HUM2	-0.1930	0.1928	-0.0510	-0.7000	0.4630	1.000		
TMAX	0.6926	0.0440	-0.4130	0.8095	-0.7720	-0.506	1.0000	
TMIN	0.4930	-0.1150	0.1036	0.1048	0.0259	-0.584	0.1719	1

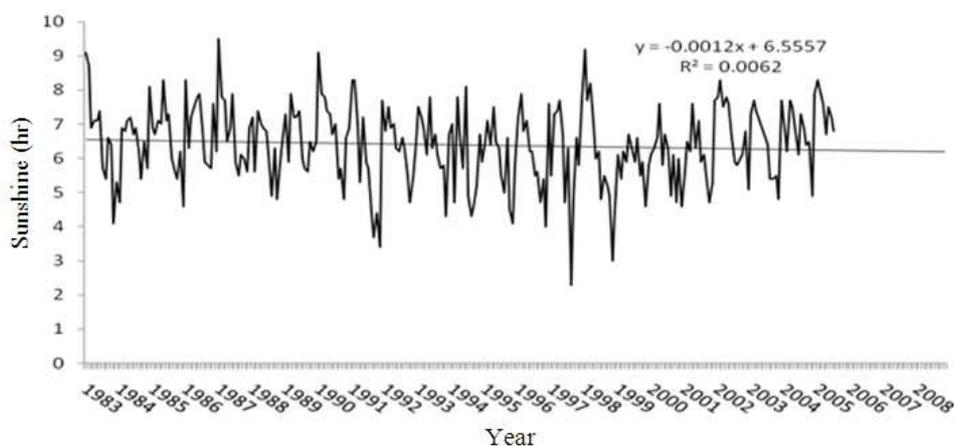


Fig. 5. Daily sunshine hours for the years 1983-2005 at NWS-IADA, Tg. Karang, Selangor, Malaysia

#### 4. CONCLUSION

The climate trend in the studied area shows that its impact on the local paddy productivity rate negligible though insufficient rains is received during the off season; the water shortage is remedied through the existing local irrigation scheme. This in turn sustained a stable level of daily humidity percentage which is crucial in the growth development of the paddy plant (Groisman *et al.*, 1999; Toriman, 2010; Kiyosawa and Aimi, 1959). The suitability of the studied area as a paddy planting area is apparent as the weather trend displayed is rather stable and the effects of climate change phenomenon are vaguely perceptible through the annual report of paddy production yield which displayed a positive annual increase despite reports of declining planting area. Though the existing irrigation scheme is sufficient to replenish the fields during low precipitation season, a planting system that require less water should be developed for the future development of the paddy planting system in less favorable conditions such as an alternate days submerge irrigation schemes instead of conventional fully submerge irrigation schemes which requires a great volume of water.

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#### 6. REFERENCES

- Alam, M.M.D., C. Siwar, R.I. Molla, M.E. Toriman and B. Talib, 2010. Socioeconomic impacts of climatic change on paddy cultivation: An empirical investigation in Malaysia. *J. Knowl. Globalizat.*, 3: 71-84.
- Alam, M.M.D., M.E. Toriman, C. Siwar and B. Talib, 2011. Rainfall variation and changing pattern of agricultural cycle. *Am. J. Environ. Sci.*, 7: 82-89. DOI: 10.3844/ajessp.2011.82.89.
- Al-Amin, A.Q. and C. Siwar, 2008. The economic dimensions of climate change: Impacts and adaptation practices in Malaysia. *Proceedings of the 9th International Business Research Conference*, Nov. 24-26, Novotel Hotel, Melbourne, Australia.
- Belinda, Y. and K. Leon, 2009. Climate change and urban planning in southeast Asia. *S.A.P.I.E.N.S.*, 2: 1-11.
- Ebrahim, A., M. Khandan, H.R. Bozorgi, S.M. Sadeghi and M. Rezaei, 2009. Response of rice varieties to water limit conditions in North Iran. *World Applied Sci. J.*, 6: 1190-1192.
- Grist, D.H., 1983. *Rice*. Longman Group Limited. Singapore National Printers Ltd., Singapore.
- Groisman, P.Y., T.R. Karl, D.R. Easterling, R.W. Knight and P.F. Jamason, 1999. Changes in the probability of heavy precipitation: Important indicators of climatic change. *Climate Change*, 42: 243-283. DOI: 10.1023/A: 1005432803188

- IADA, 2009a. Integrated agriculture development agency Malaysia. Annual Report, Malaysia.
- IADA, 2009b. Annual report of crop cutting survey integrated agriculture development agency. Malaysia.
- ICDC, 2002. Malaysian committee of international commission on irrigation and drainage. Annual Report, Malaysia.
- Kiyosawa, S. and R. Aimi, 1959. The influence of temperature and shading on the development of the rice panicle. *Proc. Crop Sci. Soc. Japan*, 27: 417-21. DOI: 10.1626/jcs.27.417
- Latif, A.B.I., 1991. The Relationship between water resource and padi cultivation in kedah: A review on the historical perspective. *J. Malaysian Stud.*, 10: 32-43.
- Mojtaba, R., H.S. Vahed, E. Amiri, M.K. Motamed and E. Azarpour, 2009. The effect of irrigation and nitrogen management on yield and water productivity of rice. *World Applied Sci. J.*, 7: 203-210.
- NRS, 2001. National response strategies to climate change. Ministry of Science, Technology and the Environment, Malaysia.
- Peng, S.B., B. Bouman, R.M. Visperas, A. Castaneda and L.X. Nie *et al.*, 2006. Comparison between aerobic and flooded rice in the tropics: Agronomic performance in an eight-season experiment. *Field Crops Res.*, 96: 252-259. DOI: 10.1016/j.fcr.2005.07.007
- Penning, D.E.V., 1993. Rice Production and Climate Change. In: *Systems Approaches for Agricultural Development*, Penning de Vries, F.W.T., P. Teng and K. Metselaar (Eds.), Springer, Dordrecht, ISBN-10: 0792318803, pp: 175-189.
- Sharfi, P. and A. Hashem, 2010. Evaluation eighteen rice genotypes in cold tolerance at germination stage. *World Applied Sci. J.*, 11: 1476-1480.
- Shi, Q., X. Zeng, M. Li, X. Tan and F. Xu, 2002. Effects of different water management practices on rice growth. *Proceedings of a Thematic Workshop on Water-Wise Rice Production*, Apr. 8-11, IRRI Headquarters in Los Banos, Philippines.
- Singh, S., R. Amartalingam, W.S. Wan Harun and M.T. Islam, 1996. Simulated impact of climate change on rice production in Peninsular Malaysia. *Proceeding of National Conference on Climate Change, (CCC' 96)*, University Putra Malaysia, Serdang, Malaysia, pp: 41-49.
- Siwar, C., M.M. Alam, M.W. Murad and A.Q. Al-Amin, 2009. A review of the linkages between climate change, agricultural sustainability and poverty in Malaysia. *Int. Rev. Bus. Res.*, 5: 309-321.
- Solomon, S., 2007. *Climate Change 2007: The Physical Science Basis*. 1st Edn., Cambridge University Press, New York, ISBN-10: 0521705967, pp: 996.
- Toriman, M.E., 2010. Assessing environmental flow modeling for water resources management: A Case of Sg. (River) Pelus, Malaysia. *Nat. Sci.*, 8: 74-81.
- Toriman, M.E., J.J. Pereira, M.B. Gasim, S. S.A. Mastura and N.A.A. Aziz, 2009. Issues of climate change and water resources in peninsular Malaysia: The case of North Kedah. *Arab World Geographer*, 12: 87-94.
- Yoshida, S., 1981. *Fundamentals of Rice Crop Science*. 1st Edn., Int. Rice Res. Inst., Manila, ISBN-10: 9711040522, pp: 269.