Research article

Drought Impact on Rice Production and Farmers' Adaptation Strategies in Northeast Thailand

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Abstract Drought is an important constraint to rice production in Thailand especially the northeastern part, as a result of the erratic distribution of rainfall. The objectives of this research were to study rainfall characteristics in northeast Thailand, assess the impact of drought on rice production in 2012 and assess adaptation to strategies of farmers relative to drought. Rainfall data over the 10 year period (2001-2011) and the drought year (2012) of northeast Thailand, as well as selected site study in Nakhonratsima and Kalasin provinces were also investigated. Mean annual rainfall recorded in 2012 was only 966 mm in Nakhonratsima which declined by 239 mm, compared to the mean annual rainfall 1204 mm in the time period during 2001-2011. Similarly, mean annual rainfall recorded in 2012 was 1133 mm in Kalasin which declined 375 mm, compared to mean annual rainfall 1508 mm in the time period between 2001-2011. The crop cutting study were done in the farmer's fields to obtain rice yield and the yield components found that the actual yield loss due to drought was 59-68% in Nakhonratsima and 55-65% in Kalasin, respectively compared with the attainable yield. Farmer's coping adaptation strategies included crop diversification (short-term adaptation options), change of land use pattern (long-term adaptation options) and built on farm pond in the paddy fields.

Keywords drought, rainfall, rice, cassava, adaptation

INTRODUCTION

Drought is the most complex of all natural hazards, and more people are affected by it then any other hazard (Hagman, 1984). Many definitions of drought exist in the literature; however, the concept of water deficit is quite a common factor among all definitions. It is defined based on the precipitation deficit that results in water shortage (Wilhite and Glantz, 1985). Drought impacts are usually first apparent in agriculture through decrease in soil moisture and high evapotranspiration. It's severity mainly depends on the level of moisture deficiency and the duration to a lesser extent. In Asia drought has affected agriculture so adversely in different parts of the continent, production of rice, maize and wheat has declined in many parts of Asia due to increasing water stress (Bates et al., 2008). Drought has a significant effect on the livelihood of rainfed lowland rice farmers (Pandey et al., 2005). However, farmers employ various coping strategies of farming households against drought, including use of irrigation, early maturity and drought resistant crop varieties, soil and water conservation practices, adjustment in agricultural input and crop diversification (Bradshaw et al., 2004; Charles and Rashid, 2007; Ashraf and Roatray, 2013).

Drought is an important constraint to agricultural production in Thailand, especially the northeastern part which has been frequently subjected to drought as a result of the erratic distribution of rainfall dry spells in the rainy season and low water holding capacity of soils. Thirteen years out of thirty four years during the period 1970-2004, namely 1972, 1973, 1974, 1977, 1979, 1981, 1982, 1987, 1993, 1996, 1997, 1998 and 2004 were drought years of northeastern, Thailand (Prapertchop et al., 2007).

OBJECTIVES

The objectives of this research were to study rainfall data in the northeastern part of Thailand and assess the impact of drought on rice yield in the drought year (2012) at selected study areas. In addition, farmer's coping with adaptation strategies in sustaining their livelihood against drought in northeastern region are also assessed.

METHODOLOGY

Selection of the Study Area

Northeastern Thailand is located between 14 ^{o} to 18 ^{o}N latitude and 100 ^{o} to 106 ^{o}E longitude. The average elevation is between 200-230 meters above mean sea level. Initially based on newspaper reports, several provinces have been declared drought disaster in northeast Thailand, Thairath, 2/11/2012. According to Mongkolsawat et al. (2001) classified drought in northeastern into three zones, namely low risk area, medium risk zone area and high risk area. Nakhonratsima and Kalasin provinces are situated in high risk area and low risk area respectively were a site selected as the study areas where is located in the south-west and the central of the northeastern (Fig. 1). Again, newspaper reports have advised that drought severely hit several districts of Nakhonratsima and Kalasin provinces (Thairath, 8,9/11/55). Then, the authors visited a few places of districts within the two provinces and consulted with the District Agricultural Extension Officer, and deciding to select Pratai and Muang districts located in Nakhonratsima and Kalasin, respectively, as the study areas. An extensive field visit was made to observe the extent and magnitude of drought. Afterwards, four villages were primarily selected in Pratai and Muang districts for the crop cutting study.

Crop Cutting Study

Four farmers who had the paddy fields located in the village were randomly selected for crop cutting study to obtained actual rice yield (sampled areas 3x2 meter) and yield components. In general, rice mostly subjected to drought at the panicle development growth stage. The attainable rice yield was estimated by employing yield components data (Yoshida, 1997) base on the assumption that drought did not occurred after the panicle development growth stage as calculated in Eq. (1) to compared with actual yield.

$$\text{Yield (tons/ha)} = \text{Spikelet number/m}^2 \times \text{grain weight} \times \text{filled grain} \times 10^{-5} \ldots\ldots\ldots (1)$$

Farmer's Adaptation Strategy Study

Field visit were done for direct observing the farmer's adaptation strategies hit by drought in such villages. Farming practices coping strategies against drought by the farmers were recorded. Rice production areas hit by drought which replaced by other crops were noticed. The crop cuttings studied were sampled to determine growth and yield, as well as economic return.

Rainfall

Data of rainfall for the time period from 2001 to 2011 of overall northeastern (27 meteorological stations) and 2012 rainfall data available from meteorological stations where located near the selected study area in Nakhonratsima and Kalasin provinces were utilized for the study. The rainfall data was analyzed to understand rainfall variability.

RESULTS

Observed Rainfall Change

In northeastern Thailand, mean annual rainfall intensity in 2012 was recorded 1,272 mm which is lower by 325 mm than for the time period 2001-2011 which showed 1596 mm (data not shown). In Nakhonratsima and Kalasin provinces a site selected in northeast showed a decreasing mean rainfall intensity in 2012 that recorded 239 mm and 375 mm respectively, in comparison with the time period 2001-2011. Among six months in the rainy season, the maximum decreased of mean annual rainfall intensity (98 mm) was observed in September of Nakhonratsima province. The maximum decrease of mean rainfall intensity (142 mm) was observed in July of Kalasin province (data not shown).

Drought Impact on Rice Production

Table 1 Yield components of rice at different villages, Pratai district, Nakhonratsima province

Village	Panicle* (no./m^2)	Filled grain ** (no./panicle)	Unfilled grain (no./panicle)	Unfilled grain (%)	1000 grains weight (g)
Donkhang	114.6	29.4	53.8	64.7	22.3
Tungsawang	98.6	38.4	55.1	58.9	24.1
Nongwaeng	101.4	21.3	38.9	64.6	21.6
Nongwaengmai	122.6	27.2	57.8	68.1	22.2
Mean	109.3	29.1	51.4	64.1	22.6

**Average from four farmers sampled, **average from 40 panicles (10 panicles/1 farmer sampled)*

Table 2 Actual yield and attainable yield of rice at different villages, Pratai district, Nakhonratsima province

Village	Actual yield* (kg/ha)	Attainable yield** (kg/ha)	Difference (kg/ha)	Reduction (%)
Donkhang	740.6	2,097.5	1,356.9	64.7
Tungsawang	908.8	2,212.5	1,303.7	58.9
Nongwaeng	453.8	1,281.9	828.1	64.6
Nongwaengmai	733.8	2,292.5	1,558.7	67.9
Mean	709.3	1,971.1	1,261.7	64.0

**Average from four farmers sampled, ** estimation base on yield components*

Crop cutting was sampled in the farmer’s fields at crop maturity growth stage. For four villages with selected site in Nakhonratsima province, the mean panicle number per square meter, filled grain number per panicle and unfilled grain number per panicle were obtained 109, 29 and 51, respectively. The mean 1,000 grains weight was received 23 g (Table 1). The unfilled grain percentage ranged from 59% to 68%, depending on locations (Table 1).

In case of grain yield, mean actual yield was obtained 709 kg/ha, while the mean attainable yield estimated about 1,971 kg/ha (Table 2). The yield different between actual yield and attainable yield showed 1,262 kg/ha with 64% reduction (Table 2). Yield reduction ranged from 59% to 68%, depending on locations (Table 2).

For the four village selected sites in Kalasin province, mean panicle number per square meter, filled grain number per panicle and unfilled grain number per panicle were obtained 112, 37 and 55, respectively. While, mean 1,000 grain weight was received 21 gm (Table 3). The unfilled grain percentage ranged from 48% to 69%, depending on locations (Table 3).

In case of grain yield, mean actual yield was obtained 848 kg/ha, while mean attainable yield estimated about 1,947 kg/ha (Table 4). The yield gab between actual yield and attainable yield showed 1,098 kg/ha with 59% reduction (Table 4). Yield reduction ranged from 55% to 65%, depending on locations (Table 4).

Table 3 Yield components of rice at different villages, Muang district, Kalasin province

Village	Panicle* (no./m^2)	Filled grain ** (no./panicle)	Unfilled grain (no.panicle)	Unfilled grain (%)	1000 grains weight (g)
Khumex	107.4	27.3	48.1	56.9	21.2
Nongkung	112.6	36.2	78.3	68.5	18.7
Joth	118.4	42.1	39.4	48.4	21.1
Najan	108.3	43.3	55.7	56.3	21.3
Mean	111.7	37.2	55.4	57.5	20.6

**Average from four farmers sampled, **average from 40 panicles (10 panicles/1 farmers sampled)*

Table 4 Actual yield and attainable yield of rice at different villages, Muang district, Kalasin province

Village	Actual yield* (kg/ha)	Attainable yield** (kg/ha)	Difference (kg/ha)	Reduction (%)
Khumex	613.8	1,488.1	874.3	58.7
Nongkung	753.8	2,155.0	1,401.2	65.1
Joth	1,040.6	1,891.9	851.3	55.0
Najan	985.0	2,251.3	1,266.3	56.2
Mean	848.3	1,946.6	1,261.7	58.8

**Average from four farmers' sampled, ** estimation base on yield components*

Farmers' Coping Adaptive Strategies towards Drought

Regarding to field visit in the areas where rice severely hit by drought in a villages selected site. Some farmers decided to plough the paddy fields in October and planted cassava replacing rice before harvest, while some farmers planted cassava after rice harvest in Kalasin province. On the other hand, some farmers decided to grow mungbean in the paddy fields after rice harvest in Nakhonratsima province. The crop cutting study was sampled for cassava in Khummex village selected site which occupied by lowland rice fields within a toposequence landform. Because of large variation in water availability among the upper toposequence position, middle position and lower position, the rainfed lowland rice can be separated into three paddy fields types, namely upper paddy, medium paddy and lower paddy. In the present study, farmers grew cassava in upper paddy and medium paddy. The author observed that farmer does not cultivated cassava in lower paddy. They mentioned that if cassava is grown in the lower paddy they may experience waterlogging early in pre-rainy season, due to lower paddy located at the bottom toposequence position. Crop cutting study was done for two farmers sampled (farmer A and B) who grew cassava in upper paddy and medium paddy in Khummex village. In the recent study, soil in cassava sampled plots are sandy in texture with low total N, available P, exchangeable K and organic matter both in upper paddy and medium paddy (Table 5). However, overall views of soil in medium paddy fields are more fertile than upper paddy (Table 5). Farmer A planted cassava in November after rice harvest while farmer B planted cassava in October before rice harvest. Cassava was harvested in June before normal rice planting. Cassava was grown in post-rainy season. Therefore, cassava must start their growth on residual soil moisture remaining in the soil and supplement with rainfall in summer season and pre-rainy season. The soil moisture contents were measured at 0-15, 15-30, 30-45 and 45-60 cm soil depth entire the growing season (Figure 1, 2 and 3). The results showed that soil moisture content (SMC) at 0-15, 15-30 cm soil depth close to the permanent wilting point (PWP) value during November to February. However, the SMC at 30-45 and 45-60 cm soil depth were mostly higher than PWP during the growing season, except their close to PWP in March and April. In general, SMC in Farmer B's sampled plots was observed to be higher than Farmer A's sampled plots. This was due to Farmer A's sampled plots being situated at higher toposequence positions than Farmer B's sampled plots, even though their classifications were the same as medium paddy type.

Table 5 Soil physical and chemical properties at 1 month after planting cassava in paddy fields, Khummex village, Muang district, Kalasin province

Farmer/Paddy field type	Total N[1] (%)	Avail.P[2] (ppm)	Exch.K[3] (ppm)	OM.[4] (%)	Field capacity[5] (%)	Permanent[6] wilting point (%)
Farmer A						
Upper paddy	0.004	2.80	28.98	0.258	5.67	1.24
Medium paddy	0.006	3.97	33.73	0.354	6.25	1.26
Farmer B						
Medium paddy	0.007	7.66	99.27	0.284	6.67	1.27

[1]Kjeldahl method; [2] BrayII and molybdenum blue method; [3]1N NH_4OAC pH7; [4]Walkey and Black method; [5,6]Pressure plate and pressure membrane apparatus

Table 6 Growth, yield and starch content of cassava at harvest, and net income of cassava grown in the paddy field at Khummex village, Muang district, Kalasin province

Farmer/Paddy field type	Plant height (cm)	Total biomass (g/plant)	Root number (no./plant)	Root yield* (kg/ha)	Starch (%)	Net income** (USD.)
Farmer A						
Upper paddy	75.9	417.5	5.5	10.9	21.8	89 (0.16 ha)
Medium paddy	91.8	583.9	6.8	18.4	20.3	530 (0.48 ha)
Farmer B						
Medium paddy	120.2	775.7	8.9	23.8	23.9	720 (0.48 ha)
Mean	95.9	592.4	7.1	17.7	22.0	

**Average from four plots randomly selected area, **net income over fertilizer cost*

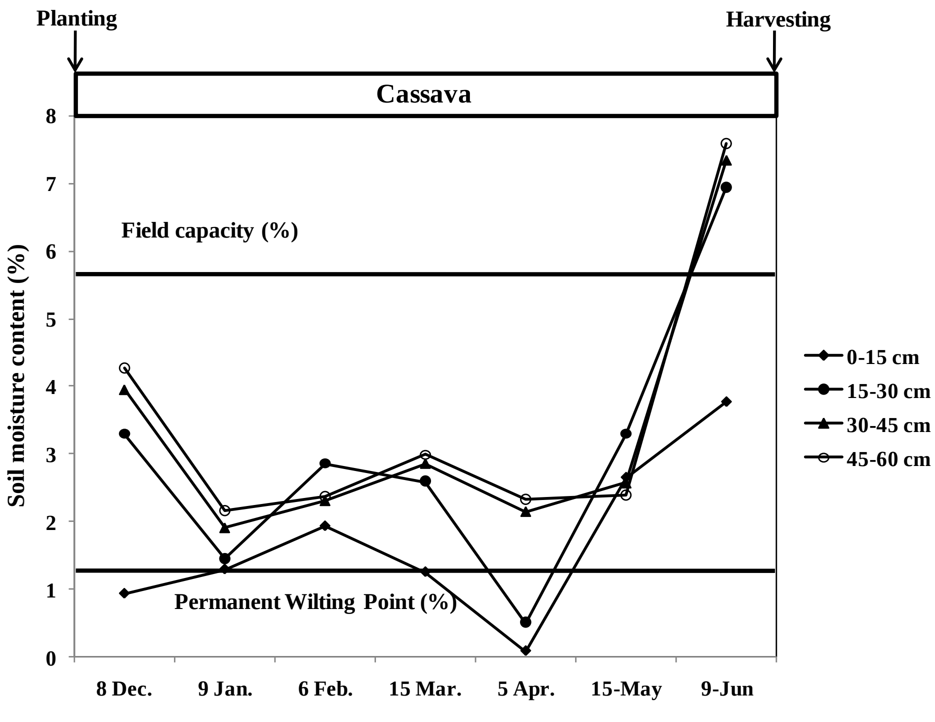

Fig. 1 Soil moisture content at 0-15, 15-30, 30-45 and 45-60 cm soil depth in upper paddy fields toposequence position (Farmer A)

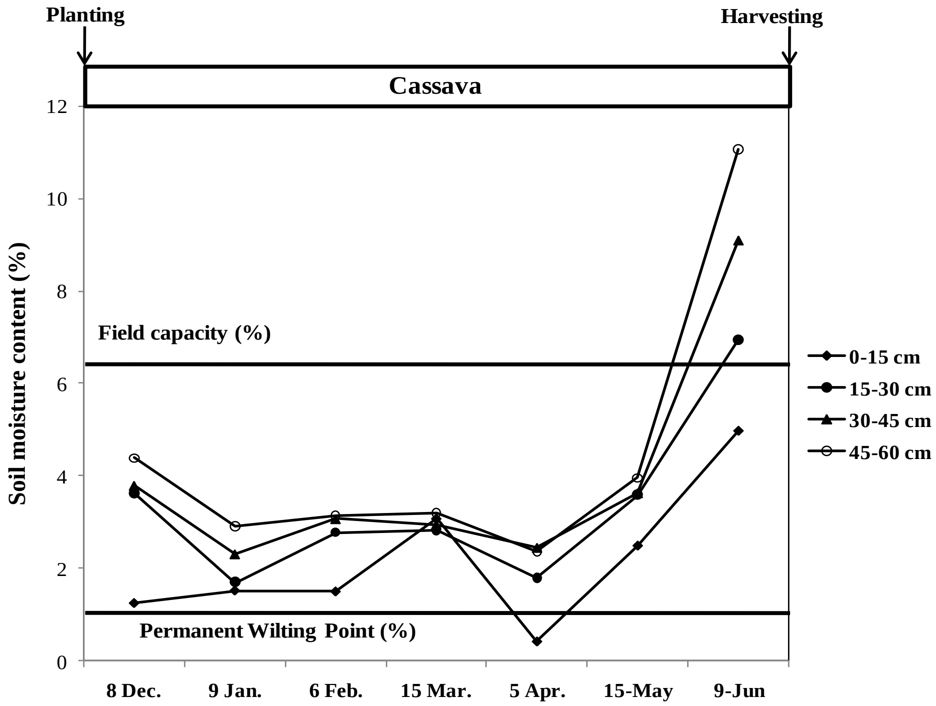

Fig. 2 Soil moisture content at 0-15, 15-30, 30-45 and 45-60 cm soil depth in medium paddy fields toposequence position (Famer A)

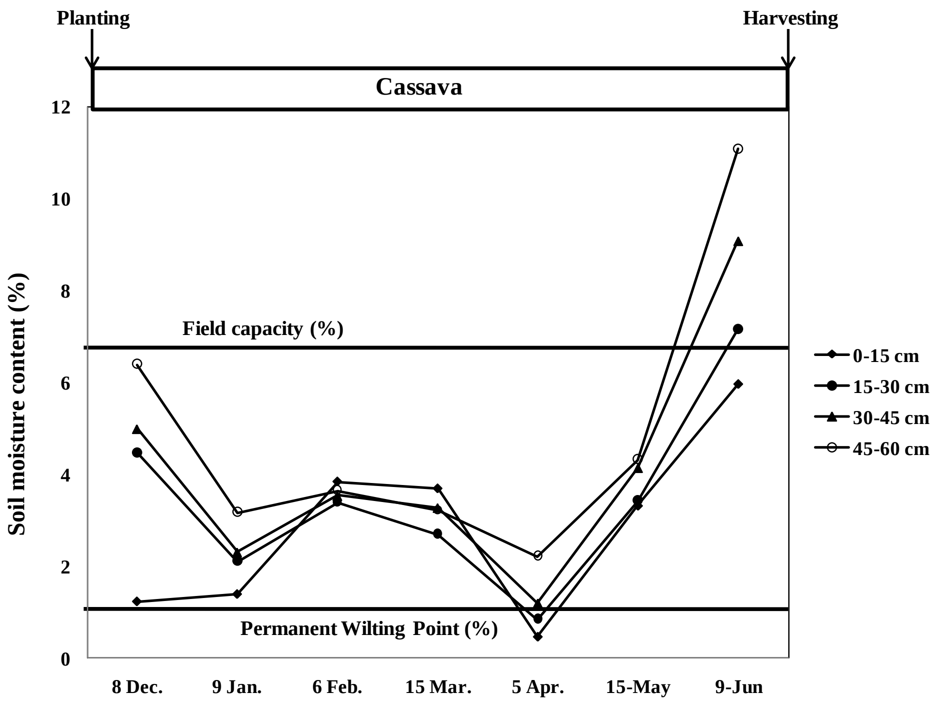

Fig. 3 Soil moisture content (%) at 0-15, 15-30, 30-45 and 45-60 cm soil depth in medium paddy fields toposequence position (Farmer B)

For cassava growth and yield, generally, the plant height, total biomass, root number and root yield obtained were higher in medium paddy than that of upper paddy (Table 6). This way is due to higher SMC in medium paddy. Mean root yield and starch content were 18 kg/ha and 22%, respectively. Farmer A received net income (gross income over fertilizer cost) 619 USD, while Farmer A earned net income 720 USD (Table 6).

Another coping adaptation strategy in Khummex village, is that farmers change land allocation by shifting rice to sugarcane especially in upper paddy fields. Some farmers built on farm pond in the upper paddy to collect water during rainy season.

In case of mungbean, the crop cutting study was done of one farmer sampled in the Naklang village selected site. The mungbean grain yield obtained was 159 kg/(0.48 ha) and provided a net income about 106 USD.

DISCUSSION

The majority of rainfed lowland areas are found in the northeast (4.8 million ha) and north (1.4 million ha) of Thailand. In the northeast, seasonal rainfall is bimodal, usually beginning in May and ending around mid October, but is highly variable. Drought may develop at anytime during the growing season. According to Gypmantasiri et al. (2003), 19% of northeast Thai farmers experienced drought while growing rice at planting stage, and 40% of them at tillering rice stage, although other 23% reported drought could affect rice growth at any growing stage.

In recent study, most rice planted areas beginning experienced to drought at panicle development stage and subsequently until harvesting, especially in the upper paddy (top position of the toposequence). Yield loss due to drought at selected site study ranged 55-68%, depending on locations. The rice yield component mainly affected by drought is the number of unfilled grains per panicle. Jongdee (2003) reported that yield loss due to drought as high as 45% in the upper paddy fields. Prapertchob et al. (2005) stated that overall loss in rice production during drought years is 56% in northeast Thailand.

In case of farmer’s coping adaptation strategies, some farmers decided to grow cassava replacing rice before maturity when they observed that rice will produced low yield. However, some farmers waited until rice reach to maturity growth stage. Then, cassava will be planted soon after rice harvest in post-rainy season. Cassava started their growth using residual soil moisture remaining in the soil and with supplement summer rainfall and pre-rainy of consequence year during the growing season. In a recent study, cassava experienced to drought during the third week of March to the third week of May. Since the cassava crop receive rainfall once the last week of January (16 mm) and the first week of March (27 mm), and prolong drought until the third week of May. Then, cassava crop received accumulate rainfall about 80 mm until harvest. Cassava is regarded as a relatively drought resistant crop (Cock, 1985). During drought, it reduces water use by following an avoidance strategy of stomatal closure (Ike, 1982) and leaf area reduction (Connor and Cock, 1981).

Regarding to mungbean, the farmers planted immediately after rice harvest. Crops growth uses residual soil moisture remaining in the soil until maturity. There is no rainfall during the growing season. Mungbean is a short growth duration crop and harvested for 65 days.

The farmers practiced growing cassava and mungbean in the paddy fields indicating that they show a large emphasis on short-term adaptation options (autonomous adaptation) against drought. Farmer A and B who grow cassava earn net income about 619 and 720 USD, respectively. While the farmers who grown mungbean received net income about 106 USD, the farm incomes received by the farmers, although, seem relatively low. But, it’s so important for livelihood of the smallholder farmers in drought year. Some farmers changes in land allocation (long-term adaptation or planned adaptation) by replacing of rice with sugarcane, especially in upper paddy fields. This means substitution of crop with high inter-annual yield variability by crop with more stable yields. Other current adaptation, some farmers devoted upper paddy fields to build on farm pond for collecting water during the rainy season.

CONCLUSION

Drought is an important constraint to crop production in northeast Thailand. In the drought year 2012, mean annual rainfall declined 239 mm and 375 mm in comparison with mean annual rainfall between the time periods 2001-2011 in selected site study of Nakhonratsima and Kalasin provinces, respectively. Rice is the main crop affected by drought. The yield lose due to drought was about 59-68% and 55-65% in Nakhonratsima and Kalasin provinces, respectively. Farmers coping adaptation strategies include both short-term and long-term adaptation options against drought.

REFERRENCES

Ashraf, M. and Routray, J K. 2013. Perception and understanding of drought and coping strategies of farming households in north-west Balochistan. International J. of Disaster Risk Reduction, (in press).

Bates, B.C., Kunzewicz, Z.W., Wu, S. and Palutikof, J.P.E. 2008. Climate change and water. Technical Paper. International Panel on Climate Change (IPCC) Secretariat, Geneva.

Bradshaw, B., Dolan, H. and Smith, B. 2004. Farm-level adaptation to climatic variability and change: Crop diversification in the Canadian prairies. Climate Change 67, 119-141.

Charles, N. and Rashid, H. 2007. Micro-level analysis of farmers' adaptation to climate change in southern Africa. IFPRI Discussion Paper 00714, Washington D.C., USA.

Cocks, J.H. 1985. Cassava. New potential for a neglected crop. Westview Press, Bouder and London.

Connor, D.J. and Cock, J.H. 1981. Response of cassava to water shortage. II. Canopy dynamics. Field Crops Res., 4, 285-296.

Gypmantasiri, P., Lim irankul, B. and Muangsuk, C. 2005. Bio-physical and socio-economic characterization of rainfed lowland rice production systems of the north and northeast of Thailand. (Available from http://www/mecweb.agri.cmu.ac.th/agsnst/publication).

Hagman, G. 1984. Prevention better than cure: Report on human and natural disasters in the third world. Stockholm, Swedish Red Cross.

Ike, I.F. 1982. Effects of water deficits on transpiration, photosynthesis and leaf conductance in cassava. Physiol. Plant., 55, 411-414.

Jongdee, B. 2003. Designing a national breeding program for developing drought tolerant rainfall lowland varieties: The Thailand experience. In: Breeding rice for drought-prone environments. Ficher, K.S., Lafitte, R., Fukai, S., Atlin, G., Hardy, B. (Eds). International Rice Research Institute, Philippines, 64-69.

Mongkolsawat, C., Thirangoon, P.,Suwanwerakantorn, R.,Karledee, N., Paiboonsak, S. 2001. An evaluation of drought risk area in northeast Thailand using remotely sensed data and GIS. Asian J. Geoinformatics. 1(4), 33-43.

Pandey, S., Behura, D.D., Villano, R., Naik, D. 2005. Economic costs of drought and farmers' coping mechanisms: A study of rainfed rice systems in Eastern India. IRRI Discussion Paper Series 39, International Rice Research Institute, Los Banos, Philippines, 35.

Prapertchop, P., Pandey, S. and Bhandari, H. 2005. Economic cost of drought and farmers' coping mechanism: A case of northeast Thailand. A Research Report Submitted to the Rockefeller Foundation. Khon Kaen, Thailand.

Prapertchop, P., Bhandari, H. and Pandey, S. 2007. Economic cost of drought and rice farmers' coping mechanism in northeast Thailand. In: Economic cost of drought and rice farmers' coping mechanisms: A cross country comparative analysis. Pandey, S., Bhandari, H., Hardy, B. (eds). International Rice Research Institute, Los Banos, Philippines, 116-148.

Wilhite, D.A. and Glantz, M.H. 1985. Understanding the drought phenomenon: The role of definitions. Water International 10(3), 111-120.

Yoshida, S. 1977. Rice. In: Ecophysiology of Tropical Crops. Alvim, P.T., Kozlowski, T.T. (eds). Academic Press, New York, San Francisco, Lonautherdon.