Pertanika J. Trop. Agric. Sci. **32 (2)**: 225 - 246 (2009)
ISSN: 1511-3701

Upland Rice Varieties in Malaysia: Agronomic and Soil Physico-Chemical Characteristics

M.M. Hanafi*, A. Hartinie, J. Shukor and T.M.M. Mahmud
Institute of Tropical Agriculture, Universiti Putra Malaysia,
43400 UPM, Serdang, Selangor, Malaysia
**E-mail: mmhanafi@agri.upm.edu.my*

ABSTRACT

Rice production is a large industry and there are a lot of opportunities which can be obtained from it. Recently, the demand for specialty and high quality rice has increased remarkably, owing to the affluent and health-conscious consumers in Malaysia. The research on upland rice has been neglected because of its low yield, though it has many good characteristics, including good fragrance and long grains. Furthermore, it has the advantage of being cultivated on dry land without accumulation of water. Therefore, a large track of idle lands in Malaysia can be developed for this purpose. This study involves a documentation of upland rice in natural conditions. Basic information on the varieties of upland rice which produce high grain yields and quality (fragrance, colour) was collected from selected locations in Peninsular Malaysia, Sabah, and Sarawak. For this purpose, both soil and plant materials (at harvest) were collected. The soil and plant materials were analysed for their macro- and micro-nutrient contents. Standard agronomic characteristics, during growing period and at harvesting time, were also measured. The data were analysed using the SAS statistical software and the mean values were then compared using the Duncan's New Multiple Range Test (DMRT) at 0.05 level of significance. Seventeen upland rice fields were identified in several locations during the course of this survey. Thirty-five (35) varieties of upland rice seeds were successfully collected. In particular, upland rice and forest soil (as a control) were acidic, contain low nitrogen content and CEC value at 0 – 20 and at 20 – 40 cm depth. Higher Fe content was also observed, with a major limitation for the growth of upland rice. Ageh, Kendinga, and Strao varieties were selected for further evaluation on nutrient requirements using an idle land soil, owing to its growth cycle, productivity, and seed availability.

Keywords: Upland rice, varieties, agronomic characteristics, physico-chemical characteristics

INTRODUCTION

In Malaysia, rice is normally cultivated either as wet paddy (Peninsular Malaysia, 503,184 ha) or upland rice (Sabah and Sarawak, 165,888 ha) (DOA, 2005). Under wet paddy cultivation, the national average yield is about 3.3 tonnes ha^{-1}, but with a better field management, varieties such as MR 219 and MR 220 can produce yields of about 10 tonnes ha^{-1} at several locations. In 2005, the total national rice production (TNRP) was approximately 2.24 million metric tonnes, which was contributed by eight granary areas; nevertheless, this only catered for 60 – 65% of the domestic requirement. Thus, Malaysia still imports 458,600 metric tonnes of rice to fulfil the requirement of its population (DOA, 2005). In addition to the large import, the rice production areas in Malaysia are decreasing because good rice areas, near development centres are being converted for other uses.

Received: 8 September 2008
Accepted: 24 March 2009
*Corresponding Author

Upland rice cultivation is practiced mostly by the rural communities living especially in Sabah and Sarawak. It is still an important agricultural activity for home consumption and sometimes the farmers sell their surplus to earn some money. Certain upland rice varieties have desirable characteristics, particularly in terms of their fragrance, colours, sizes, and shapes. These qualities contribute to their popularity among the farmers and health-conscious consumers as an organic food. However, these upland rice varieties have not been commercialized due to their low grain yields. Mariam *et al*. (1991) reported that research on upland rice has been neglected because of the low and unstable grain yields, although it is widely grown in the interior parts of the country. The average yield of the upland rice is lower and this ranges from 0.46 to 1.1 tonnes ha^{-1}. The low grain yields of the upland rice is attributed to the poor management by the farmers during the cultivation period, where fields are left unattended after sowing without any monitoring on plant nutrients and other critical aspects, such as weeds, diseases, and insect-pest attacks. Therefore, with good management practices, the application of adequate plant nutrient and water, together with weeds, diseases, and insect-pests management, the grain yields of upland rice varieties are expected to increase. All these aspects are therefore important in obtaining higher yields. At present, the nutrient supply for upland rice comes from resultant ash and it may not be sufficient to complete its life cycle and produce better yields. Therefore, it is crucial to learn about the nutrient requirements of the upland rice and the fastest way to obtain this information is through analysis of soil and plant.

The results yielded from the analysis on soil and plant would provide information on the nutrient content in soil and plant, respectively. Nutrient partitioning in plant would be useful for further evaluation on the nutrient requirements of selected upland rice varieties. Furthermore, the field operations, such as soil preparation, irrigation, and applications of fertilizers, insecticides, herbicides, and harvesting are possible using machinery and modern technology on flat land, such as idle land, which are comparably difficult in hilly areas. Therefore, a large track of idle lands in Peninsular Malaysia (649,865 ha) can be developed for food production (*http://agrolink.moa.my*). Thus, the evaluation of upland rice varieties should be carried out to identify their potential for future commercialisation on idle lands. Therefore, the objectives of this study were (i) to determine the popular upland rice varieties and their agronomic characteristics based on a survey at several locations in Malaysia, and (ii) to determine the physico-chemical characteristics of the upland rice soils and the nutrient requirements of the plant.

MATERIALS AND METHODS

Selected Upland Rice Cultivation Locations

Several high-yielding upland rice cultivation locations in Sabah, Sarawak, and Peninsular Malaysia were identified with the assistance of the Department of Agriculture (DOA) and Malaysian Palm Oil Board (MPOB). Table 1 shows the list of upland rice fields sampled. The upland rice fields were located in hilly and sloping areas. The classification of upland rice soils is listed in Table 2.

Field Survey of Upland Rice

Basic information, such as the local names of upland rice varieties, grain yield, grain characteristics, and management practices, were recorded using an open-ended questionnaire, supplemented by informal talks with farmers and the observations carried out during planting and at harvesting time. The sampling location coordinates were recorded both in longitude and latitude, using Global Positioning System (GPS) with 15 metres accuracy (Model SILVA).

Soil Sampling

The soils (upland rice field and undisturbed forest areas) were randomly sampled at several points, using an auger at 0 – 20 and 20 – 40 cm depths. The forest soils adjacent to each upland

TABLE 1
The locations of the upland rice fields and their GPS coordinates from the selected locations in Malaysia

Marks[@]	Field locations	GPS coordinate	
		Latitude	Longitude
SSR1	Kg. Kujang Mawang, Tebedu	0°58.301^N	110°25.681^E
SSR2	Sg. Mujong, Kapit (Rh. Anding)	2°03.305^N	113°16.476^E
SSR3	Sg. Mujong, Kapit (Rh. Anding)	2°03.463^N	113°15.350^E
SSR4	Baleh, Kapit (Rh. Milang)	2°01.560^N	113°07.458^E
SSB1	Kg. Hamad, Tuaran	6°06.389^N	116°20.561^E
SSB2	Kg. Bonggol, Tuaran	6°06.737^N	116°24.454^E
SSB3	Kg. Timbang, Kota Belud	6°29.477^N	116°32.488^E
SSB4	Kg. Timbang, Kota Belud	6°29.522^N	116°33.324^E
SSB5	Kg. Tangkol, Kota Marudu	6°21.035^N	116°44.289^E
SSB6	Kg. Kiawayan, Tambunan	5°38.435^N	116°18.145^E
SSB7	Kg. Kiawayan, Tambunan	5°38.520^N	116°18.177^E
SSB8	Kg. Baru Jumpa, Tenom	4°56.722^N	115°52.966^E
SSB9	Kg. Baru Jumpa, Tenom	4°56.763^N	115°53.667^E
SPH1	RPS Betau, Kuala Lipis	4°16.138^N	101°41.019^E
SPH2	RPS Buntu, Raub	3°59.349^N	101°39.063^E
SPH3	Kg. Sg. Mai, Jerantut	3°51.051^N	102°20.075^E
SPH4	Lembah Kiol, Jerantut	3°52.216^N	102°19.118^E

[@] SSR1 = Kg. Kujang Mawang, Tebedu; SSR2 = Sg. Mujong, Kapit (Rh. Anding); SSR3 = Sg. Mujong, Kapit (Rh. Anding); SSR4 = Baleh, Kapit (Rh. Milang); SSB1 = Kg. Hamad, Tuaran;SSB2 = Kg. Bonggol, Tuaran; SSB3 = Kg. Timbang, Kota Belud; SSB4 = Kg. Timbang, Kota Belud; SSB5 = Kg. Tangkol, Kota Marudu; SSB6 = Kg. Kiawayan, Tambunan; SSB7 = Kg. Kiawayan, Tambunan; SSB8 = Kg. Baru Jumpa, Tenom; SSB9 = Kg. Baru Jumpa, Tenom; SPH1 = RPS Betau, Kuala Lipis; SPH2 = RPS Buntu, Raub; SPH3 = Kg. Sg. Mai, Jerantut; and SPH4 = Lembah Kiol, Jerantut.

rice field, which were not subjected to burning, were considered as the control for soil physico-chemical characteristics. The soils sampled at each depth were combined to give a composite sample for each area. These soil samples were air-dried, ground, and sieved to pass through a 2.0-mm sieve size. The samples were then kept in labelled plastic containers for further analysis.

Plant Sampling and Agronomic Variables

At harvest, three healthy upland rice hills from each location were randomly sampled. The following variables were measured: the number of tillers per hill, the number of panicles and the weight of roots, straw, panicles (with and without grains), grains (with and without panicles) at 14% moisture, 1000 grain weight and the percentage of unfilled grains. In the laboratory, these plant samples were separated into roots, straw, panicles, and grains. These samples were then oven-dried at 60 °C for two days, weighed, and ground, to pass through a 2.0- mm sieve size. The samples were kept in the self-adhesive labelled plastic bags for further analysis.

Soil and Plant Analysis

The pH of soil was determined using the pH water (pH_W) and pH KCl (pH_{KCl}) methods at a ratio of 1: 2.5 soil to water; the total N in the soil was determined using the Kjeldahl method (Bremner 1960); the plant availability of P was

TABLE 2
The classification of the upland rice soils in Sarawak, Sabah and Pahang, Malaysia

Marks	Soil series/ Family	Description[@]
SSR1	Merit	Member of the family of fine, mixed, isohyperthermic, yellow Allik Tualemkuts, sedimentary rocks (shale, mudstone, sand stone), well to moderately well drained soils, fine sandy clay texture, argilic horizon, low base saturation, typically occur on rolling, hilly area (6 – 25° slopes) at elevations of less than 330 m (1,000 ft).
SSR2 SSR3 SSR4	Kapit Kapit Kapit	Member of the Kapit family, which is a fine-loamy, siliceous, isohyperthermic, Tipik Distroparadanks, weathered sedimentary rocks (West Sarawak granite, diorite, gabbro), within 50 cm of soil surface, moderately well to well drained soils, have a cambic horizon, low base saturation (< 50%), occur at hilly to steep terrain, steep slopes and the shallow soil depth (unsuitable for agriculture).
SSB1 SSB2	Tanjong Lipat Tanjong Lipat	Member of the Tanjong Lipat family which is a fine, loamy, siliceous, Tanjong Lipat isohyperthermic, red-yellow to yellow Allik Tualemkuts, mixed sedimentary rocks dominated by arenaceous material (sandstone/shale), deep well drained profiles with good permeability, fine sandy clay loam textures, brown to yellowish brown and an argilic horizon, occurs on rolling, hilly, and steep terrain (slopes in excess of 12% or 6°) at an elevation of more than 50 m (150 ft), low CEC, low fertility status and erodability.
SSB3 SSB4	Laab Laab	Dystric cambisol, fine loamy, siliceous, isohyperthermic, yellow (sedimentary rocks), mudstone, sandstone and limestone, highly leached and low base saturation, brownish or reddish color of subsoil, well drained, loamy texture.
SSB5	-na	-na
SSB6	Kapilit	Typic Kandiudults, coarse-loamy, siliceous, isohyperthermic, red yellow (sandstone), deep well drained profile, have a kandic horizon, clay distribution pattern that decreased by more than 20% from its maximum within 100 cm of the mineral soil surface.
SSB7	Kumansi	Typic Paleudults, fine, mixed, isohyperthermic, red-yellow (mudstone/shale), deep and well drained profile, do not have a kandic horizon, clay distribution pattern that decreased by more than 20% from its maximum within 100 cm of the mineral soil surface.
SSB8 SSB9	Luasong Luasong	Dystric cambisol, fine, kaolinitic, isohyperthermic, red (sedimentary rocks), coastal and riverine alluvium, highly leached and low base saturation, brownish or reddish color of subsoil, well drained, loamy texture.
SPH1	-na	Schist, phyllite, slate and limestone. Sandstone and volcanic (rock type)
SPH2	-na	Schist, phyllite, slate and limestone. Sandstone and volcanic (rock type)
SPH3 SPH4	Jempol Jempol	Typic Paleudults, fine, kaolinitic, isohyperthermic, brown (tuffaceous shale, acid to intermediate volcanics), deep and well drained profile, do not have a kandic horizon, clay distribution pattern that decreased by more than 20% from its maximum within 100 cm of the mineral soil surface

[@] sources: S. Paramanathan (1998, 2000)
-[na] = information not available due to landform > 25° slope

extracted using the Bray and Kurtz No. 2 method (Bray and Kurtz, 1945) with 2 g soil in 20 mL extractant (1:2; soil/solution ratio); the cation exchange capacity (CEC) and exchangeable bases (K, Ca, and Mg) were determined using the leaching method (Piper, 1950); the aluminium in soil was extracted using 1N KCl and the Al in the solution was measured using the AAS; iron in soil was extracted using the double acid method (0.05 M HCl with 0.0125 M H_2SO_4) at 1:5 soil/solution ratio; the total organic carbon of the soil samples was determined using a Leco® CR-412 T.O.C analyzer; the texture of soil samples was determined using the pipette method (Day, 1965); and the measure of soil moisture tension (pF) on soil dry weight basis was carried out using the pressure plate apparatus based on the soil dry weight basis at pF 0, 1, 2, 2.54, and 4.19. The available water capacity was determined by calculating the difference in the soil moisture content between pF 2.54 and 4.19. Meanwhile, the plant samples (leaves, grains, and roots) were determined using the wet digestion method (Thomas *et al*., 1967). The N, P, and K contents in the solution were measured using an autoanlyser (AA), whereas Ca, Mg, Fe, and Al were measured using the atomic absorption spectrometer (AAS).

Statistical Analysis

The analysis of variance (ANOVA) was carried out using the PROC ANOVA of the Statistical Analysis System (SAS, 2001). The Duncan's New Multiple Range Test (DMRT) was used for the comparison of the mean values when the treatment effects were significant.

RESULTS AND DISCUSSION

The Survey of the Upland Rice Cultivation

The current status

The survey of selected upland rice fields, carried out in October 2003 (first visit) and in February 2004 (second visit), showed that the upland rice cultivation in Malaysia was poor in terms of technology and innovation; therefore, most farmers still practiced shifting cultivation using the slash-and-burn technique.

Field location

Seventeen upland rice fields were selected at various locations in Pahang (4), Sarawak (4), and Sabah (9). The upland rice fields in Sarawak (Kapit) were located in remote areas and can only be accessed using a long boat. The other fields located in Sarawak (Tebedu), Sabah (Tuaran, Kota Belud, Tambunan, Tenom) and Pahang (Raub, Jerantut, Kuala Lipis) were easily accessible with a four-wheel drive vehicle. The topography of these selected upland rice fields varied greatly from the lowland areas to steep hills as well as on the mountain ranges (0 – 500 m). The landscape of most upland rice fields in South and Southeast Asia is level to gently rolling (0 – 80% slope) land (Greenland 1983). According to Mariam *et al*. (1991), the exploitation of forest for timber has probably encouraged cultivators to shift more often and into more remote areas than before, as they take advantage of the partially cleared forest left by the loggers for upland rice cultivation. The observations carried out during the survey indicated that large proportion of the hilly areas was still covered with secondary forest or under cultivation. The GPS coordinates of the selected upland rice fields are listed in Table 1.

Cultural practices

With the exception of Lembah Kiol, Jerantut (SPH4), Pahang, most farmers were found to still practice shifting cultivation (traditional system), in which forest land was cleared using the slash-and-burn technique, cultivated with rice for one or two years, and then abandoned for 3 to 5 years. Fallow is an essential component of the shifting cultivation because it permits a re-growth of the forest species and restores soil fertility. Shorter fallow period, ranging from 3 to 5 years, has been practiced by the farmers at all locations to fulfill the increasing food demands of an expanding population. According to Deegan (1980), the average fallow period of the upland rice cultivation in Sarawak was 7 years, while 48% of the fields were left fallow for 5 years or less, 34% for 6 to 11 years, and 17% for 12 years or longer. This study showed that all the farmers followed the same basic procedures in the planting of upland rice, such as in land preparation, planting, maintenance, and harvesting. The farmers also intercropped upland rice with short-cycle crops, such as vegetables, cassava, banana, corn, and groundnut at the early growth stages (Table 3). Teng (1991) reported that upland rice farmers in Sarawak also planted maize, tapioca, pumpkin, cucumber, and ginger as the inter-crops in the same fields (Photo 1).

At all locations, seeding was done using a dibbler randomly at planting distances of 30 to 40 cm. Five to six seeds were dropped in each seeding hole which was covered with soil. According to Gupta and Toole (1986), shifting cultivation practices were simple and involved mostly hand tools. Rocks or stumps in the fields did not affect cultivation. This technique was practiced without imposing any disturbance to the ecosystem (Arraudeau, 1983) and able to reduce soil erosion as compared to mechanical clearing (Lal, 1982). The survey also showed that only three of the 17 farmers applied fertilisers by broadcasting methods, and this was found at Kg. Kujang Mawang, Tebedu (SSR1) in Sarawak, and at RPS Betau, Kuala Lipis (SPH1) and at Kg. Sg. Mai, Jerantut (SPH3) in Pahang (Table 3). In Tebedu, Sarawak, the farmers used amorfous (16% N and 48% P_2O_5) fertilisers obtained from the government under the fertiliser subsidy scheme (Table 3). The farmers were unwilling to mix chemical fertilisers with the rice seed because the seeds became wet and sticky, and this caused difficulties during the dibbling time.

The farmers at Kg. Kujang Mawang, Tebedu (SSR1), Kg. Timbang, Kota Belud (SSB3), and Kg. Sg. Mai, Jerantut (SPH3) used herbicides (Paraquat) during land preparation and after germination of weeds, and this was usually done a week after burning (Table 3). During upland rice growing season, weeding was done manually once or twice by the farmers without applying any chemicals. As an input cost-reduction measure, no pesticides and fungicides were applied.

At all locations, upland rice was harvested by hand. During harvesting, all family members and other farmers cooperatively took turn in rotation to expedite the activity (Photo 2). Most farmers used the grains previously harvested for home-consumption and only sold their surplus to earn extra income.

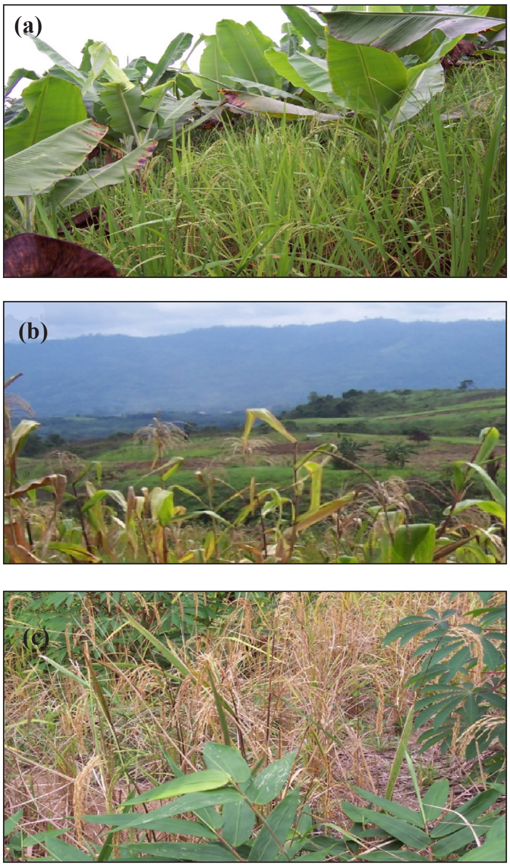

Photo 1: Intercropping of upland rice with other crops: a) Banana, b) Corn, and c) Tapioca

Varieties

The characteristics of upland rice, such as colours, fragrance, and shapes, were the main considerations for the farmers in selecting a

TABLE 3
Cultural practices used in the upland rice fields in several locations in Malaysia

Marks[@]	Cultivation technique	Other crops	Fertilisation	Herbicide
SSR1	Shifting	Corn, Cucumber	Amorfous	Paraquat
SSR2	Shifting	Corn	Nil	Nil
SSR3	Shifting	Corn, Cassava	Nil	Nil
SSR4	Shifting	Nil	Nil	Nil
SSB1	Shifting	Nil	Nil	Nil
SSB2	Shifting	Cassava, Banana	Nil	Nil
SSB3	Shifting	Cassava, Banana	Nil	Paraquat
SSB4	Shifting	Cassava, Banana	Nil	Nil
SSB5	Shifting	Cassava, Banana	Nil	Nil
SSB6	Shifting	Nil	Nil	Nil
SSB7	Shifting	Nil	Nil	Nil
SSB8	Shifting	Corn	Nil	Nil
SSB9	Shifting	Corn	Nil	Nil
SPH1	Shifting	Cassava	Nil	Nil
SPH2	Shifting	Cassava	Nil	Nil
SPH3	Shifting	Corn, Banana, Groundnut	NPK	Paraquat
SPH4	Permanent	Banana	Nil	Nil

[@] SSR1 = Kg. Kujang Mawang, Tebedu; SSR2 = Sg. Mujong, Kapit (Rh. Anding); SSR3 = Sg.Mujong,Kapit (Rh. Anding); SSR4 = Baleh, Kapit (Rh. Milang); SSB1 = Kg. Hamad, Tuaran; SSB2 = Kg. Bonggol, Tuaran; SSB3 = Kg. Timbang, Kota Belud; SSB4 = Kg. Timbang, Kota Belud; SSB5 = Kg.Tangkol, Kota Marudu; SSB6 = Kg. Kiawayan, Tambunan; SSB7 = Kg. Kiawayan, Tambunan; SSB8 = Kg. Baru Jumpa, Tenom; SSB9 = Kg. Baru Jumpa, Tenom; SPH1 = RPS Betau, Kuala Lipis; SPH2 = RPS Buntu, Raub; SPH3 = Kg. Sg. Mai, Jerantut; SPH4 = Lembah Kiol, Jerantut

Photo 2: Cooperation among farmers in all stages of upland rice activity: a) Harvesting of paddy, b) Assembling, and c) Threshing

certain rice variety for planting. In this study, a total of 35 varieties of upland rice seeds were collected from the upland rice farmers at various locations in Malaysia, including Sabah and Sarawak (Table 4). These varieties have been inherited from the previous generation of farmers.

The rice varieties were named by the farmers based on their characteristics, origin, or by maintaining the ancestral name. Therefore, the origin of a variety may be the same but it may have two different names at different locations or districts. Mariam et al. (1991) reported that the varieties with different names might sometimes belong to the same variety when some of these varieties were introduced to places with different ethnic backgrounds.

It is important to highlight the fact that farmers had several upland rice varieties in their collections (Table 4), but they only planted selected varieties (Photo 3). A particular variety of the upland rice was selected for the cultivation based frequently on their preferences, such as fragrance, taste, and texture of the rice (Table 5).

The survey showed that the cultivated upland rice varieties required 4 to 6 months to complete their growth and produce grain yields (Table 5). The growth cycle of the upland rice varieties varied with early maturing rice varieties (90 – 105 days), medium varieties (105 – 130 days), and late-maturing (130 – 150 days) (Jacquot and Courtois, 1987). Teng (1991) observed that almost all upland rice farmers in Sarawak planted late-maturing varieties (150 to 180 days) and these varieties have been selected for planting through generations.

Planting seasons

The upland rice planting season and the duration were found to greatly differ markedly according to the locations and rainfall distributions. Table 6 lists the planting duration of the selected upland rice fields. Basically, the farmers involved in the survey practiced the ‘slash-and-burn’ activity during the dry season for easier burning process. During the wet season, sowing of the upland rice seeds was continued as there was an adequate supply of soil moisture by the rains to promote seed germination. Rains during the early growth stage usually resulted in better yields. However, heavy rains could result in poor emergence because of seed loss through soil erosion. Lal (1982) reported that shifting cultivation followed a definite pattern, whereby forest was cleared

TABLE 4
The seeds of the upland rice collected during the field survey in Malaysia

Location	Variety
SSR1	Lawi
SSR2 and SSR3	Sarikei, Pulut Sibau, Ukir, Pulut Kawat, Gerung, Seribu, Lentik, Nibong, Sapunak, Kucing, Pakan, Sangking, Ngigit
SSR4	Sebilit, Menalam, Strao, Pulut Besar, Singut, Badang
SSB1 and SSB2	Kendinga, Kungkulob
SSB3 and SSB4	Sarawak, Dorok, But, Ageh
SSB5	Paulok
SSB6 and SSB7	Merah
SSB8 and SSB9	Kendinga, Keninga, Dusun
SPH1	Siam
SPH2	Kurau
SPH3	Liba pasir
SPH4	Siam

Photo 3: Some upland varieties in the fields

TABLE 5
The cultivated upland rice varieties, at the time of survey and the corresponding locations in Malaysia

Location	Variety	Growth cycle (month)
SSR1	Lawi	6
SSR2	Lentik	5
SSR3	Ukir	5
SSR4	Strao	6
SSB1	Kungkulob	5
SSB2	Kendinga	5
SSB3	But	5
SSB4	Dorok	5
SSB5	Paulok	5
SSB6	Merah	5
SSB7	Merah	5
SSB8	Kendinga	4
SSB9	Keninga	4
SPH1	Siam	5
SPH2	Kurau	5
SPH3	Liba pasir	5
SPH4	Siam	5

*SSR1= Kg. Kujang Mawang, Tebedu; SSR2 = Sg. Mujong, Kapit (Rh. Anding); SSR3 = Sg. Mujong, Kapit (Rh. Anding); SSR4 = Baleh, Kapit (Rh. Milang); SSB1 = Kg. Hamad, Tuaran; SSB2 = Kg. Bonggol, Tuaran; SSB3 = Kg. Timbang, Kota Belud; SSB4 = Kg. Timbang, Kota Belud; SSB5 = Kg. Tangkol, Kota Marudu; SSB6 = Kg. Kiawayan, Tambunan; SSB7 = Kg.Kiawayan, Tambunan; SSB8 = Kg. Baru Jumpa, Tenom; SSB9 = Kg. Baru Jumpa, Tenom; SPH1 = RPS Betau, Kuala Lipis; SPH2 = RPS Buntu, Raub; SPH3 = Kg. Sg. Mai, Jerantut; SPH4 = Lembah Kiol, Jerantut

TABLE 6
Planting duration of selected upland rice fields by district in Malaysia

Location	Preparation	Planting	Harvesting
Tebedu (SSR1)	August	September	March
Kapit (SSR2 and SSR3)	July	July/August	January/February
Tuaran (SSB1 and SSB2)	July	August	December/January
Kota Belud (SSB3 and SSB4)	July	August	December/January
Kota Marudu (SSB5)	July	August	January
Tambunan (SSB6 and SSB7)	July	August	January
Tenom (SSB8 and SSB9)	August	September	January
Kuala Lipis (SPH1)	July	August	January
Raub (SPH2)	August	September	February
Jerantut (SPH3 and SPH4)	November	December	April

*SSR1 = Kg. Kujang Mawang, Tebedu; SSR2 = Sg. Mujong, Kapit (Rh. Anding); SSR3 = Sg. Mujong, Kapit (Rh. Anding); SSR4 = Baleh, Kapit (Rh. Milang); SSB1 = Kg. Hamad, Tuaran; SSB2 = Kg. Bonggol, Tuaran; SSB3 = Kg. Timbang, Kota Belud; SSB4 = Kg. Timbang, Kota Belud; SSB5 = Kg. Tangkol, Kota Marudu; SSB6 = Kg. Kiawayan, Tambunan; SSB7 = Kg. Kiawayan, Tambunan; SSB8 = Kg. Baru Jumpa, Tenom; SSB9 = Kg. Baru Jumpa, Tenom; SPH1 = RPS Betau, Kuala Lipis; SPH2 = RPS Buntu, Raub; SPH3 = Kg. Sg. Mai, Jerantut; SPH4 = Lembah Kiol, Jerantut

in the dry season, the cut trees and bushes were left to dry and were burned just before the rainy season. Therefore, the correct timing to complete all major operations, such as land preparation and sowing is critically important, as the farmers will otherwise lose their food supply for the next year.

Rice yield

Upland rice is considered as a home-consumption crop. Therefore, most of the farmers have no record on the performance of their cultivated varieties. The farmers in Sabah and Sarawak used the term "karong" or "tong" to record their harvested yields. According to DOA, a full "karong" and "tong" contain about 50 to 60 kg and 30 to 40 kg grains, respectively. The farmers at each surveyed location stated that the yield of the upland rice was low and unstable. Similar results were also reported by Mariam *et al*. (1991), i.e. low and unstable grain yield were attributed to poor management, cultural practices, and the use of the local non-hybrid varieties. Available record on the surveyed upland rice yield was obtained for the Kendinga variety at Kampung Baru Jumpa (Tenom, Sabah), which was 25 – 30 "karong ha^{-1}" (1.8 tonne ha^{-1}). Benong *et al*. (1989) reported that the yield of 23 early-maturing upland rice varieties was between 1.2 and 3.8 tonne ha^{-1}. Therefore, the results of the survey concluded that the upland rice has the potential to produce higher yields. However, it is totally dependent on the varieties used, the size of fields, cultural practices, and field management, since the interaction of these factors has a great effect on the yield of upland rice.

Major constraints in the cultivation of upland rice

Blast and brown spot diseases and the symptoms of nutrient deficiency were the main problems observed in all locations (Photo 4). In addition, the competition was observed between weed and upland rice for the plant nutrients, water, sunlight, and space (Photo 5). The weed, insect-pest, and disease problems can be solved using the chemical methods for better results. Under shifting cultivation, upland rice yield is low because the farmers do not apply any chemical fertilisers and are dependent only on the resultant ash from the burning process. Although the varieties have fewer tillers, the number of filled grains can be increased with the application of fertiliser and improved water management. The cultivation of upland rice can be considered as a high-risk activity because it is carried out in hilly and steep sloped areas. Therefore, the cultivation of upland rice in flat land area is less risky and all field management practices are easily applicable. Consequently, the yield and quality of rice grain can be improved.

Potential

This survey suggests that the collected upland rice varieties have not been fully exploited for commercial production. Furthermore, the majority of the upland rice farmers are dependent only on the nutrient in the soil without

Photo 4: The most common symptom of nutrient deficiency, and pest and diseases of upland rice

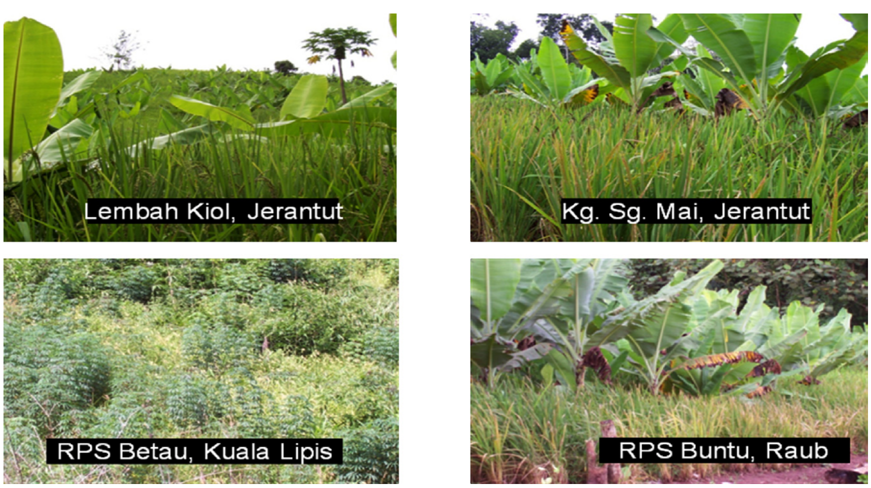

Photo 5: Competition between weeds and upland rice for plant nutrients, water, sunlight, and space in the field

the addition of any chemical fertilisers and their management practices are also not well organized. Therefore, with proper management practices, such as fertilisation, irrigation, weeds and disease management, the performance of upland rice varieties could be improved, particularly in terms of their grain quality and yields.

The Characteristics of Soil

With the exception of clay content, the mean sand and silt contents of upland rice soils were higher in the subsoil (20 – 40 cm depth) as compared to the topsoil (0 – 20 cm depth) (Table 7). The majority of the identified upland rice soils in the top part belong to the sandy clay loam (70%) texture, followed by the sandy loam (24%) and clay loam (6%) textures. Meanwhile, the proportion of the sandy clay loam texture was found to decrease to 18% and the sandy loam texture was increased to 59% for the subsoil. The control soil under virgin forest vegetation showed almost similar particle size distribution values as in the same soil under upland rice cultivation. With higher percentage of the sandy soils type, the upland rice soils are more permeable to air, water, and roots, which are suitable for crop growth, but the limitation includes lower water-holding capacities and poor retention of plant nutrients, due to the small surface areas of its particles. Therefore, adequate water and nutrient supply is crucial to achieve high crop productivity. The texture of the upland rice soils varied widely and this is because of the different parent materials and the degree of soil development. Most of the soils in the surveyed areas were developed from highly weathered sedimentary rocks, low base saturation, CEC, and fertility (Table 2). The soils from basic rocks are mostly clayey, while the soils from intermediate rocks are mainly coarse loamy near the surface and fine loamy to fine clayey in the subsoil (Moormann and Breemen, 1978). With higher distribution of sandy clay loam in the topsoil and sandy loam texture in the subsoil, the upland rice soils tend to have low water-holding capacity in the former than the latter. Moormann and Veldkamp (1978) stated that the abundant, sandy, coarse texture of West Africa upland rice soils limit their production because of the low water-retention capacity. The texture of the upland rice soils may strongly influence the mean percentage water content in the soils. The mean percentage water content was found to decrease with the increasing soil moisture tension, while the pF values were lower in the subsoil as compared to the topsoil. Fine-textured soils hold more water than the coarse-textured soils. Therefore, the higher clay percentage content in the top portion of the upland rice soil influences the mean percentage of the water content and the available water capacity (AWC). However, higher moisture condition, under forest vegetation, was attributed to a slightly higher AWC of these soils, as compared to the upland rice soils (Table 7).

The selected chemical characteristics of the upland and forest soils showed that the values of the topsoil were higher than the subsoil (Table 8). The means soil pH, as measured by pH_w and pH_{KCl} for the upland and forest soils, were similar (with the values of 4.3 and 3.3) for the former and the latter. The means C and N values were also similar for both soils (~3.5% C and 0.17%N). However, for P, K, Ca, and Mg, these were substantially higher in the upland rice than that of the forest soils. The status of the P content for the upland rice soils (28.5 mg P kg^{-1} soil) and the forest soils (24.4 mg P kg^{-1} soil) was higher, based on the routine soil chemical analysis interpretation carried out by Landon (1991). However, there were low, medium, and high for K, Ca, and Mg, respectively (Table 8). On the other hand, Fe and Al were substantially higher in the forest soils as compared to the upland rice soils (Table 8). Nevertheless, the values for Al were low (34.7 and 26.1 mg kg^{-1} soil) and Fe were higher (477.3 and 455.9 mg kg^{-1} soil) than those given by Landon (1991). In all the cases, the CEC of both soils were low at almost similar value (~10.0 $cmol_c\ kg^{-1}$ soil). Kato *et al*. (1999) reported that greater amount of ash, which was obtained from burning of 10-year-old forest vegetation, increased the soil pH up to 6.5 as compared to the 4-year-old

TABLE 7
Some physico-chemical characteristics of the upland rice and forest soils from various locations in Malaysia

Soil depth		Particle size distribution			Soil pF at		
		Sand	Silt	Clay	2.54	4.19	Available water
cm		%					
a) Upland rice soil							
0 – 20	Mean	59	16	24	28.44	14.47	14
	Max	77	27	40	46.51	28.42	18
	Min	35	8	6	16.07	6.48	10
20 – 40	Mean	62	23	15	28.83	12.24	15
	Max	75	36	26	41.22	21.99	19
	Min	38	13	5	15.24	6.67	9
b) Forest soil							
0 – 20	Mean	59	14	26	30.19	15.38	15
	Max	72	27	38	47.49	28.81	19
	Min	35	8	13	18.21	5.26	13
20 – 40	Mean	59	15	26	29.06	13.15	16
	Max	79	33	44	48.26	23.37	25
	Min	29	5	13	15.04	5.25	10

secondary vegetation (pH 6.0). The total N of the upland rice and forest soils can be considered as low and they showed similar characteristics of the upland tropical soils which are low in their content of nutrient. Therefore, burning of upland rice soil during land clearing did not result in any significant loss of the total N in the topsoil, but a slight increase in N was observed when a greater number of herbaceous leguminous plants capable of symbiotic N_2 fixation or fibrous-rooted plants (i.e. grasses) were burned (Pritchett, 1979). De Bano *et al*. (1998) reported that fire could also organically mineralise bound elements, such as N, P, and base cations, but the availability of these nutrients remained uncertain (Fisher and Binkley, 2000). According to Gupta and Toole (1986), the availability of nutrient in non-fertilised rice soils depends on the parent materials and the degree of weathering or soil formation. Therefore, the results of this study suggested that the slash-and-burn technique practiced by the upland rice farmers could provide certain plant nutrients and increase the pH of soil.

Agronomic Characteristics of the Upland Rice

Number of tillers

There were highly significant differences ($P \leq 0.05$) between the numbers of tillers of the upland rice varieties (Table 9). The number of tillers of selected upland rice varieties ranged from 10 to 18 tillers $hill^{-1}$. Lentik variety (SSR2) showed the highest number of plant (18 tillers $hill^{-1}$), whereas the lowest number of tillers was obtained by Strao and Kurau varieties (10 tillers $hill^{-1}$).

Number of panicles

There were also highly significant differences ($P \leq 0.05$) between the numbers of panicles of

TABLE 8
Selected chemical characteristics of the upland rice and forest soils from various locations in Malaysia

Soil depth		pH_w	pH_{KCl}	C	N	P	K	Ca	Mg	Fe	Al	CEC
cm				%		mg kg^{-1}						$cmol_c$ kg^{-1}
a) Upland rice soil												
0 – 20	Min	4.29	3.33	1.00	0.10	20.40	92.70	2.40	23.20	80.00	1.60	3.41
	Max	6.48	6.07	6.50	0.26	65.60	240.60	218.90	132.30	1085.00	79.60	15.51
	Mean#	5.21	4.02	3.54	0.17	28.51	152.28	50.71	68.90	455.88	26.05	10.45
20 – 40	Min	4.46	3.34	0.44	0.07	7.90	42.70	2.10	9.40	98.75	6.30	2.29
	Max	6.37	5.00	3.31	0.18	44.40	220.10	153.00	125.70	697.50	115.20	12.92
	Mean#	5.13	3.84	1.89	0.12	15.66	82.16	33.83	52.86	376.69	26.01	9.06
b) Forest soil												
0 – 20	Min	4.32	3.31	0.93	0.13	7.8	66.40	2.00	14.10	47.50	1.60	2.76
	Max	6.91	5.50	6.47	0.24	41.70	305.90	132.10	130.80	1010.00	92.50	16.94
	Mean#	5.10	3.96	3.48	0.17	24.43	111.49	37.64	55.84	477.28	34.72	10.83
20 – 40	Min	4.37	3.29	0.47	0.08	6.70	33.50	1.10	9.20	147.50	1.10	3.22
	Max	6.18	4.47	4.35	0.18	30.10	357.70	113.30	129.40	728.75	69.20	15.83
	Mean#	4.99	3.80	2.22	0.13	13.18	80.29	36.27	48.92	437.79	23.03	10.07

Note: # Mean = mean of 17 locations, [light grey] = low, [medium grey] = medium, and [dark grey] = high based on routine soil chemical analysis interpretation by Landon (1991).

the upland rice varieties (Table 9). The number of the panicles of upland rice varieties ranged from 7 to 14 panicles hill^{-1} (Table 9). Lawi variety (SSR1) showed the highest number of panicles (14 panicle hill^{-1}), whereas Ukir variety (SSR3) showed the lowest number of panicles (7 panicles hill^{-1}).

Empty grains

There were highly significant differences ($P \leq 0.05$) between the empty grains of the upland rice varieties (Table 9). The empty grains ranged from 10 to 19% and these values correspond to Keninga (SSB9) and Ukir (SSR3) varieties, respectively.

Grain yields

There were highly significant differences ($P \leq 0.05$) between the grain yields of the upland rice varieties (Table 9). In this study, the grain yields of the upland rice varieties ranged from 21 to 50 g hill^{-1}. The highest (50.96 g hill^{-1}) grain yield was observed for Lentik variety (SSR2) and the lowest (21.34 g hill^{-1}) was obtained from Kungkulob variety (SSB1).

Grain yield per panicle

There were highly significant differences ($P \leq 0.05$) between the grain yields per panicle for the upland rice varieties (Table 9). The highest grain yield per panicle was observed for Liba pasir variety (SPH3), which was 5.92 g panicle^{-1}, whereas the lowest (2.25 g panicle^{-1}) yield was obtained from Dorok variety (SSB1).

Dry matter partitioning

The dry matter weight of each plant part of the upland rice varieties was found to remarkably vary (Table 10). Straw constituted the highest proportion of total dry matter, followed by grains, and roots; this suggests that straw is an important dry matter sink, particularly with the larger leaf blades of upland rice, which affect the photosynthesis efficiency and hence the production of dry matter. It was observed that the dry matter partitioning of upland rice varieties ranged between 44 and 61% (straw), 10 and 37% (roots), and 18 and 36% (grains). Meanwhile, the highest straw dry matter weight (121.25 g hill^{-1}) was obtained from Merah variety (SSB6) and the lowest (51.24 g hill^{-1}) from Kungkulob variety (SSB1). The highest dry matter percentage of the roots was obtained by Kungkulob variety (SSB1), which was 27% higher than the Lawi variety (SSR1). The results indicated that Kungkulob rice variety (43.15 g hill^{-1}) had a higher root surface area for nutrient uptake, as compared to Lawi variety (11.02 g hill^{-1}). It was also observed that the upland rice varieties, with a higher proportion of straw and roots dry matter, had a lower grain dry matter weight, indicating that the potential of several upland rice varieties to transfer the photosynthetic products from the panicles into spikelets is highly variable.

Therefore, selecting the upland rice variety, with a higher yield potential, is crucial so as to achieve reasonable grain yields. Lentik (SSR2), Merah (SSB6), and Liba Pasir varieties (SPH3) showed the highest total dry matter weights than other upland rice varieties with the values of 208.71, 198.63 and 169.15 g hill^{-1}, respectively. Among these selected upland rice varieties, Lawi variety (SSR1) had the highest harvest index (0.40), indicating its efficiency to produce grain yields as compared to the other varieties. As expected, a higher total dry matter weight per plant translates into a higher grain yield. This could be achieved by increasing the number of plants per hill or increasing the plant density. The analysis showed that increasing the productivity of the upland rice yield can be realised either by increasing the harvest index or improving the total biomass.

Nutrient partitioning

Highly significant differences ($P \leq 0.05$) were observed for the total nutrients (N, P, K, Ca, Mg, Fe, and Al) storage, between the three plant parts of the upland rice varieties. Specific nutrient partitioning in the dry matter of the upland rice varieties was measured (data did not present).

TABLE 9
Agronomic parameters of the upland rice varieties at harvest from various locations in Malaysia[@]

Location	Variety	No. of Tillers	No. of panicles	Empty grain	Yield^{GW}	Yield$^{A/Pc}$
		—— Tiller or Panicle hill^{-1} ——		— % — — g hill^{-1} —	—— g panicle^{-1} ——	
SSR1	Lawi	17 ab	14 a	16.40 abc	38.35 abc	3.23 cdefg
SSR2	Lentik	18 a	12 ab	12.60 bcd	50.96 a	3.99 bcdef
SSR3	Ukir	14 abc	7 b	19.51 a	24.29 cd	3.14 defg
SSR4	Strao	10 c	9 ab	16.74 ab	22.80 d	2.71 efg
SSB1	Kungkulob	11 c	9 ab	16.81 ab	21.34 d	2.43 fg
SSB2	Kendinga	11 c	9 ab	13.88 bcd	31.60 bcd	3.53 bcdefg
SSB3	But	11 bc	9 ab	14.34 bcd	32.04 bcd	3.50 bcdefg
SSB4	Dorok	12 bc	10 ab	12.57 bcd	22.60 d	2.25 g
SSB5	Paulok	-	-	-	-	-
SSB6	Merah	13 abc	11 ab	11.64 d	45.58 ab	4.18 bcde
SSB7	Merah	11 c	9 ab	12.00 d	45.18 ab	4.85 abc
SSB8	Kendinga	11 c	10 ab	12.24 bcd	32.63 bcd	3.24 cdefg
SSB9	Keninga	13 abc	10 ab	10.49 d	33.81 bcd	3.27 cdefg
SPH1	Siam	12 bc	8 b	10.65 d	40.68 ab	4.78 abcd
SPH2	Kurau	10 c	8 b	13.75 bcd	40.84 ab	5.11 ab
SPH3	Liba pasir	12 bc	8 b	13.06 bcd	47.30 ab	5.92 a
SPH4	Siam	11 c	9 ab	11.65 d	40.58 ab	4.80 abcd

[@] Means in a column with the same letters are not significantly different at 5% level by DMRT.
^{GW}= Gross weight $^{A/Pc}$=Average yield per panicle.

TABLE 10
Dry matter partitioning and harvest index of the upland rice varieties from various locations in Malaysia

Location	Variety	Straw	Root	Grain	Total	Harvest index	Total@
		g hill^{-1}					g plant^{-1}
SSR1	Lawi	57.01 (53.59)	11.02 (10.36)	38.35 (36.05)	106.37 (100)	0.40	6.26
SSR2	Lentik	116.34 (55.74)	41.40 (19.84)	50.96 (24.42)	208.71 (100)	0.30	11.59
SSR3	Ukir	77.65 (59.52)	28.51 (21.85)	24.29 (18.62)	130.45 (100)	0.24	9.32
SSR4	Strao	57.90 (55.43)	23.75 (22.74)	22.80 (21.83)	104.45 (100)	0.28	10.45
SSB1	Kungkulob	51.24 (44.28)	43.15 (37.29)	21.34 (18.44)	115.73 (100)	0.29	10.52
SSB2	Kendinga	61.02 (51.16)	26.65 (22.35)	31.60 (26.49)	119.27 (100)	0.34	10.84
SSB3	But	83.86 (58.68)	27.01 (18.90)	32.04 (22.42)	142.91 (100)	0.28	12.99
SSB4	Dorok	56.43 (52.09)	29.29 (27.04)	22.60 (20.86)	108.32 (100)	0.29	9.03
SSB5	Paulok	- -	- -	- -	- -	- -	- -
SSB6	Merah	121.25 (61.04)	31.80 (16.01)	45.58 (22.95)	198.63 (100)	0.27	15.28
SSB7	Merah	81.50 (53.88)	24.59 (16.26)	45.18 (29.86)	151.27 (100)	0.36	13.75
SSB8	Kendinga	53.85 (48.72)	24.05 (21.76)	32.63 (29.52)	110.53 (100)	0.38	10.05
SSB9	Keninga	61.91 (50.94)	25.82 (21.24)	33.81 (27.82)	121.54 (100)	0.35	9.35
SPH1	Siam	76.57 (51.64)	31.03 (20.92)	40.68 (27.43)	148.27 (100)	0.35	12.36
SPH2	Kurau	78.09 (50.93)	34.38 (22.43)	40.84 (26.64)	153.31 (100)	0.34	12.78
SPH3	L.Pasir	84.38 (49.89)	37.47 (22.15)	47.3 (27.96)	169.15 (100)	0.36	16.92
SPH4	Siam	72.21 (50.95)	28.94 (20.42)	40.58 (28.63)	141.73 (100)	0.36	12.88

@( ) = % of the total weight
Total = Weight per plant

$$\text{Harvest index: } \frac{\text{Grain dry matter}}{\text{Grain + Straw dry matter}}$$

The highest storage of the total plant nutrients was observed in straw, followed by roots and grains (*Fig. 1*). The results showed that more than 50% of the nutrients accumulated in straw before being transferred and used for grain production.

Fig. 1: Total nutrient storage in the dry matter of the upland rice varieties collected at several locations in Malaysia

Highly significant differences ($P \leq 0.05$) were observed in the nutrient partitioning in the total dry matter between the upland rice varieties (Table 11). The observed nutrients in the total dry matter of the upland rice were between 26 and 46% N, 6 and 13% P, 16 and 54% K, 0.30 and 5.6% Ca, 1 and 4% Mg, 2 and 7% Fe, and 3 and 21% Al, suggesting that the upland rice require higher N and K, as compared to the other nutrients to complete their growth cycle and produce grains. It was also observed that the partitioning of N and K in the upland rice varieties was an inverse relationship, since a deficiency in one or both nutrients could cause a yield loss. A balanced N and K fertilisation enhances the growth and improves the uptake of both nutrients, which in turn reduces nitrate losses, during and after the cropping season. The quality of the yield is also dependent on the NK ratio and the fertiliser grades (Marchand and Bourrie, 1998). However, the partitioning of P in the upland rice was less, as compared to N and K. The poor partitioning of P in the upland rice varieties may be due to the lack of soil available P. According to Pande (1994), the availability of P in the upland rice soil was lower than that of the flooded soils; hence, P deficiency may be a limiting factor in the upland soils, particularly in strongly acidic Oxisols.

The highest partitioning of N (46.77%) and Mg (4.07%) was observed in But variety (SSB3), whereas that for P (13.30%), K (54.15%), and Ca (5.60%) was observed in Lawi (SSR1), Kurau (SPH2), and Kendinga (SSB2) varieties, respectively. Dorok variety (SSB4) showed the highest Fe (7.61%) and Al (21.06%). Meanwhile, the lowest partitioning of N (26.42%) and Fe (2.05%) was observed in Kurau variety (SPH2), and that for K (51.67%) was observed in Dorok variety, and P (6.70%) in Merah variety (SSB6), while Ca (0.34%), Mg (1.85%) and Al (3.69%) was observed in Siam (SPH1), Siam (SPH4), and Lawi (SSR1) varieties, respectively (Table 11).

Nutrient uptake

There were highly significant differences ($P \leq 0.05$) in the nutrient uptake between the upland rice varieties (Table 12). The nutrient uptake (in g $hill^{-1}$) by the upland rice varieties was found to range between 0.7 and 1.9 for N, 0.19 and 0.50 for P, 0.45 and 2.55 for K, 0.01 and 0.17 for Ca, 0.05 and 0.14 for Mg, 0.05 and 0.23 for Fe, and 0.06 and 0.60 for Al. Santos *et al*. (1982) also reported that the uptake of N and K was the highest in the upland rice, followed by Ca, Mg, P, and S; whereas, the highest uptake for the micronutrient was Fe, followed by Mn, Zn, Cu, and B. The nutrient uptake varied with the different growth stages and this increased with the age of plant. Therefore, the timing of plant sampling had an effect on the results of the nutrient uptake. The highest N (1.97 g $hill^{-1}$), P (0.50 g $hill^{-1}$), and Fe (0.23 g $hill^{-1}$) uptakes were observed in Liba pasir (SPH3) variety, whereas the highest Ca (0.17 g $hill^{-1}$) and Al (0.60 g $hill^{-1}$) uptakes were observed in Merah (SSB6) variety. The highest uptake of K (2.55 g $hill^{-1}$) and Mg (0.14 g $hill^{-1}$) was observed in Kurau (SPH2) and Lentik (SSR2) varieties, respectively. Meanwhile, the lowest N (0.74 g $hill^{-1}$), P (0.19 g $hill^{-1}$), and Ca (0.01

TABLE 11
Nutrient partitioning in total dry matter of upland rice varieties at harvest from various locations in Malaysia[@]

Location	Variety	N	P	K	Ca	Mg	Fe	Al
		%[b]						
SSR1	Lawi	43.88 ab	13.30 a	30.77 ef	2.26 bcde	2.77 bc	3.31 def	3.69 g
SSR2	Lentik	34.92 cd	8.40 cde	43.14 b	2.44 bcd	2.93 b	2.93 def	5.21 fg
SSR3	Ukir	33.39 d	8.76 cde	42.20 bc	1.73 cdef	2.13 cde	3.78 cde	8.00 defg
SSR4	Strao	34.72 cd	10.41 bc	38.84 bcd	1.26 cdef	2.40 bcde	4.02 bcde	8.33 defg
SSB1	Kungkulob	45.97 a	8.19 cde	18.13 g	1.51 cdef	2.40 bcde	5.42 bc	18.35 ab
SSB2	Kendinga	31.82 de	9.57 bcd	28.73 f	5.60 a	3.05 b	5.72 b	15.49 bc
SSB3	But	46.77 a	11.46 ab	17.84 g	1.78 cdef	4.07 a	5.64 b	12.42 cd
SSB4	Dorok	43.42 ab	7.87 cde	16.55 g	0.89 def	2.57 bcd	7.61 a	21.06 a
SSB5	Paulok	-	-	-	-	-	-	-
SSB6	Merah	38.44 bcd	6.70 e	32.45 def	3.34 b	2.70 bc	4.25 bcde	12.09 cd
SSB7	Merah	36.75 cd	8.21 cde	42.30 bc	1.77 cdef	2.55 bcd	2.65 ef	5.74 fg
SSB8	Kendinga	35.81 cd	10.41 bc	39.46 bcd	2.70 bc	3.76 a	3.10 def	4.74 fg
SSB9	Keninga	40.97 abc	7.38 de	40.93 bc	1.13 cdef	2.81 b	2.68 ef	4.08 g
SPH1	Siam	36.03cd	8.96 bcde	37.95 bcd	0.34 f	1.98 de	4.14 bcde	10.57 de
SPH2	Kurau	26.42 e	7.78 cde	54.15 a	0.70 ef	1.93 de	2.05 f	6.92 efg
SPH3	Liba pasir	37.39 bcd	9.39 bcde	35.17 cdef	2.29 bcde	2.43 bcde	4.45 bcd	8.86 def
SPH4	Siam	37.95 bcd	8.33 cde	36.66 bcde	0.35 f	1.85 e	4.01 bcde	10.82 de

[@] Means in a column with the same letters are not significantly different at 5% level by DMRT

[b] $\% \text{ Nutrient} = \left[\frac{\text{Nutrient concentration} \times \text{Total dry matter weight}}{\text{Total nutrient in the whole plant}} \times 100\right]$

TABLE 12
Nutrient uptake by the different upland rice varieties at harvest from various locations in Malaysia[@]

Location	Variety	N	P	K	Ca	Mg	Fe	Al	Total[b]
		g $hill^{-1}$							
SSR1	Lawi	0.76 d	0.23 cd	0.52 fg	0.04 c	0.05 e	0.05 d	0.06 d	1.71 e
SSR2	Lentik	1.72 abc	0.40 ab	2.12 ab	0.12 ab	0.14 a	0.15 abcd	0.27 bcd	4.91 ab
SSR3	Ukir	1.05 d	0.28 bcd	1.37 cde	0.06 bc	0.07 de	0.12 bcd	0.25 abc	3.2 bcde
SSR4	Strao	0.74 d	0.22 cd	0.83 defg	0.03 c	0.05 e	0.08 d	0.18 cd	2.13 de
SSB1	Kungkulob	1.11 cd	0.19 d	0.45 g	0.04 c	0.05 e	0.13 abcd	0.45 abc	2.42 de
SSB2	Kendinga	0.77 d	0.23 cd	0.70 efg	0.14 a	0.07 de	0.14 abcd	0.37 abcd	2.42 de
SSB3	But	1.23 bcd	0.30 bcd	0.47 g	0.05 c	0.10 abcd	0.15 abcd	0.33 abcd	2.63 de
SSB4	Dorok	1.08 cd	0.21 d	0.45 g	0.02 c	0.06 de	0.21 abc	0.57 ab	2.60 de
SSB5	Paulok	-	-	-	-	-	-	-	-
SSB6	Merah	1.83 ab	0.31 bcd	1.47 bcd	0.17 a	0.13 abc	0.21 ab	0.60 a	4.72 ab
SSB7	Merah	1.30 bcd	0.28 bcd	1.56 bcd	0.07 bc	0.09 bcde	0.10 cd	0.21 cd	3.61 abcd
SSB8	Kendinga	0.75 d	0.23 cd	0.84 defg	0.05 c	0.08 cde	0.06 d	0.10 d	2.11 de
SSB9	Keninga	1.21 bcd	0.22 cd	1.21 cdef	0.03 c	0.08 cde	0.08 d	0.12 d	2.95 cde
SPH1	Siam	1.27 bcd	0.32 bcd	1.35 cde	0.01 c	0.07 de	0.15 abcd	0.37 abcd	3.54 abcde
SPH2	Kurau	1.24 bcd	0.37 bc	2.55 a	0.03 c	0.09 bcde	0.09 cd	0.32 abcd	4.69 abc
SPH3	Liba pasir	1.97 a	0.50 a	1.85 bc	0.12 ab	0.13 ab	0.23 a	0.47 abc	5.27 a
SPH4	Siam	1.24 bcd	0.29 bcd	1.36 cde	0.03 c	0.07 de	0.13 abcd	0.35 abcd	3.47 bcde

[@]Means in a column with the same letters are not significantly different at 5% level by DMRT
[b]Total = Total uptake

g hill^{-1}) uptakes were observed in Strao (SSR4), Kungkulob (SSB1), and Siam (SPH1) varieties, respectively. Kungkulob, and Dorok varieties showed the lowest K uptake (0.45 g hill^{-1} each), and the lowest uptake of Mg (0.05 g hill^{-1}) was observed in Lawi (SSR1), Strao (SSR4), and Kungkulob (SSB1) varieties. In summary, the total nutrient uptake of the selected upland rice varieties ranged from 1 to 5 g hill^{-1}, while the highest and lowest total nutrient uptakes were observed in Liba pasir (SPH3) and Lawi (SSR1) varieties, with the mean values of 5.27 g hill^{-1} and 1.71 g hill^{-1}, respectively. These values would be used as a basis for further evaluation in the glasshouse and in the field for fertiliser recommendation practices.

CONCLUSIONS

The cultivation of the upland rice crop is still an important activity for the rural community as it provides them with staple foods. Most upland rice farmers in Sarawak, Sabah, and Peninsular Malaysia are practicing a shifting cultivation using the slash-and-burn technique for land clearing. This is also used as a method to control weeds, insect-pest, and diseases. Three out of the 17 locations surveyed showed that the farmers applied fertiliser, such as amorfous (SSR1) and NPK fertiliser (SPH1 and SPH3), and used paraquat as herbicide (SSR1, SSB3 and SPH3). The number of tillers, panicles, and grain yields of the selected upland rice varieties ranged from 10 to 18 tillers hill^{-1}, 7 to 14 panicles hill^{-1}, 21 to 50 g grain yield hill^{-1}, respectively. Meanwhile, the uptake of N, P, and K in the upland rice varieties ranged from 80 to 211 kg N ha^{-1}, 20 to 53 kg P ha^{-1}, and 20 to 272 kg K ha^{-1}; these quantities would be used as a guide for fertiliser application rates in the glasshouse and field experiments. Ageh, Kendinga, and Strao varieties, which were early, medium, and late-maturing varieties, would respectively be selected for further evaluation on the nutrient requirements, using an idle land soil due to its growth cycle, productivity, and seed availability.

ACKNOWLEDGEMENT

We wish to thank the Ministry of Science, Technology, and Innovation (MOSTI) for providing a research grant (54038100) through the Intensification of Research in Priority Areas (IRPA) and the National Science Fellowship (NSF) to Miss H.A.

REFERENCES

Arraudeau, M. (1983). Upland rice cropping systems in Western Africa. In *Shifting cultivation. Upland Rice: A Global Perspective*. IRRI Los Banos Philippines. pp 64.

Benong, M.B., Narimah, M.K., Mariam, A.L. and Kamarudin, M.S. (1989). Sumber-sumber genetik beberapa tanaman dan buah-buhan tempatan di Sabah. *Bengkel Penyelidikan IRPA/ UKM Pertama*, 2 – 3 September, Melaka.

Bray, R.H. and Kurtz, L.T. (1945). Determination on total organic and available form of phosphorus in soils. *Soil Science, 59,* 39 – 45.

Bremmer, J.M. (1965). Total nitrogen. In C.A. Black *et al*. (Eds.), *Methods of soils analysis*. Part 2. *Chemical and microbiological properties (*pp. 1149 – 1178). Wisconsin, USA: Amer. Soc. Agron.

Day P.R. (1965). Particle fractionation and particle size analysis. In C.A. Black (Ed.), *Methods of soil analysis* (pp. 545 – 567). Part 1, Agronomy No. 9. Wisconsin: Am. Soc. of Agron. Madison.

DeBano, L.F.R., Neary, D.G. and Folliott, P.F. (1998). *Fire's Effects on Ecosystems*. New York: Wiley.

Deegan, J.L. (1980). Deviation from optimum fallow periods for dry rice fields in Sarawak: The effects on rice production. *Southeast Asian Studies*, *17*, 756 – 764.

DOA. (2005). *Agriculture Statistical Handbook*. Ministry of Agriculture and Agro-based Industry. pp. 31.

Fisher, R.F. and Binkley, D. (2000). Ecology and management of forest soils. In *Fire Effects* (pp. 241 – 261). John Wiley & Sons, Inc.

Greenland, D.J. (1983). Characteristics of upland rice soils of the world. In *Upland Rice: A Global Perspective*. Philippines: IRRI, Los Banos.

Gupta, P.C. and O'Toole, J.C. (1986). *Upland Rice: A Global Perspective*. IRRI.

Jacquot, M. and Courtois, B. (1987). The rice plant. In *Upland Rice*. Macmillan Publishers.

Kato, M.S.A., Kato, O.R., Denich, M. and Vlek, P.L.G. (1999). Fire-free alternatives to slash-and-burn for shifting cultivation in the eastern Amazon region:- the role of fertilizers. *Field Crops Research, 62,* 225 – 237.

Lal, R. (1982). Effective conservation farming system for humid tropics. Soil erosion and conservation in the tropics. ASA Spec. Publ. 43., Madison, Wisconsin, USA. pp 65.

Landon, J.R. (ed.). (1991). *Booker Tropical Soil Manual*. UK: Longman, Burnt Mill, Harlow, UK.

Marchand M. and Bourrie, B. (1998). Use of potash fertilizers through different application methods for high yield and quality crops. In *Improved Crop Quality by Nutrient Management Workshop* (pp. 13 – 17). Bornova, Izmir, Turkey.

Mariam, A.L., Masahuling, B. and Jamilah, I. (1991). Hill paddy cultivation in Sabah. *Sabah Society Journal 9*(3)*,* 284 – 289.

Moormann, F.R. and Breeman, V.N. (1978). *Rice: Soil, Water and, Land*. Philippines: IRRI, Los Banos.

Moormann, P.R. and Veldkamp, W.J. (1978). Land and rice in Africa: Constraints and potential. In *Rice in Africa*. London: Academic Press. Pp. 29 – 44.

Pande H.K. (1994). Improved upland rice farming systems. In *Seeds and seeding*. Food and Agriculture Organization of the United Nations Rome. Pp. 31 – 39.

Piper, C.S. (1950). *Soil and Plant Analysis*. Adelaide, Australia: University of Adelaide.

Pritchett, W.L. (1979). *Properties and Management of Forest Soils*. New York, USA: Wiley.

Santos, A., Dos, B., Fageria, N.K. and de Carvalho, J.R.P. (1982). Effects of two different technologies on growth, yield and nutrient uptake by upland rice. *Pseq. Agropecu. Bras*., *17*(7), 1041 – 1050.

SAS Institute Inc. (2001). *Statistics Analysis System*. Version 8.02. NC, USA: Cary.

Teng, C.S. (1991). Shifting cultivation of hill paddy. A traditional method utilizing and managing natural soil fertility for rice production in Sarawak. Department of Agriculture Kuching, Sarawak.

Thomas, R.L., Sheard, W.W. and Moyer, J.R. (1967). Comparison of conventional and automated procedures of N, P, K analyses of plant materials using a single digestion. *Agronomy Journal, 59,* 240 – 243.