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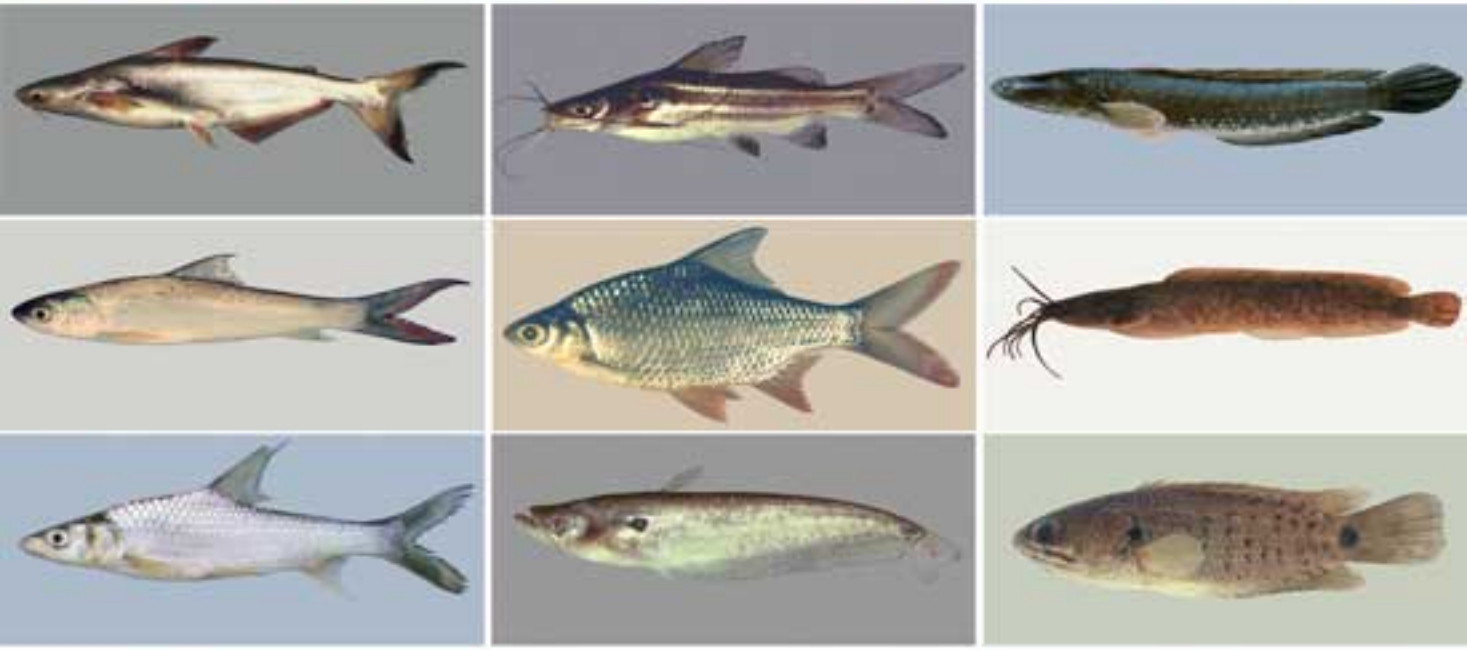

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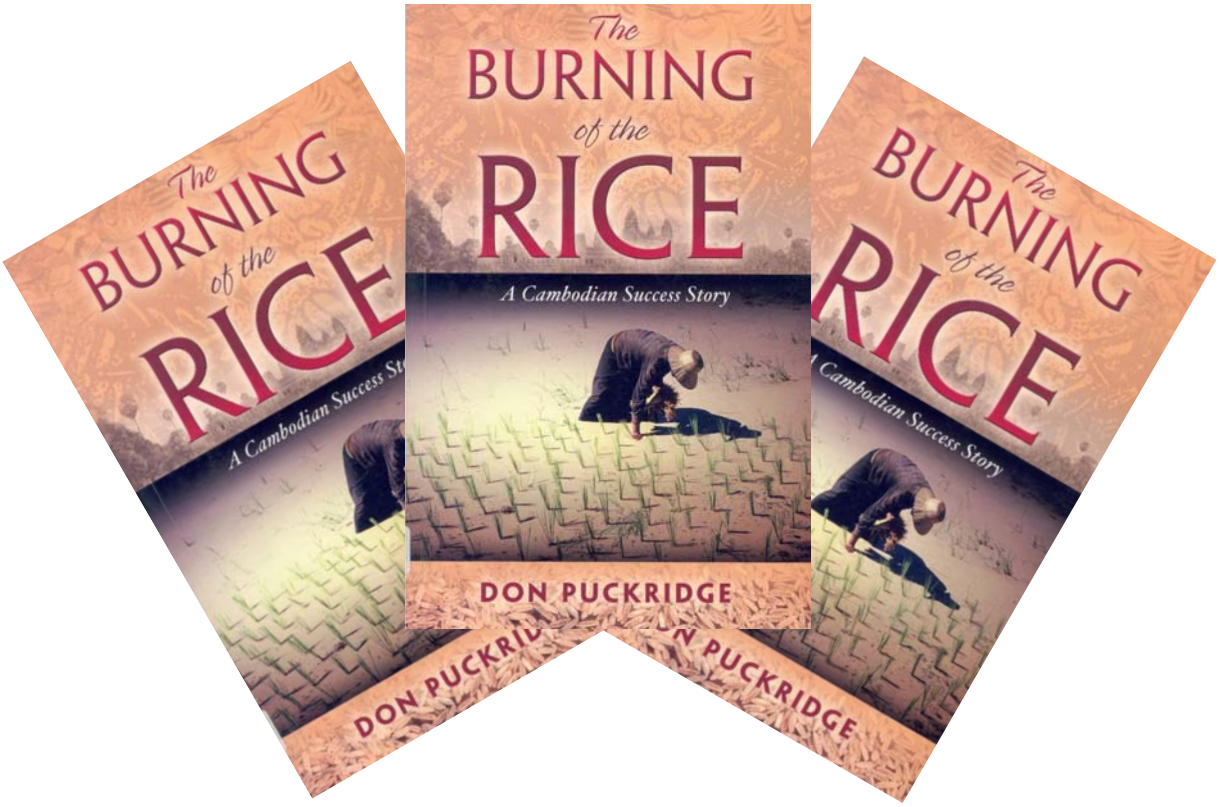

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FISH ECOLOGY AND COMMUNITY STRUCTURE IN TONLE SAP LAKE, CAMBODIA

Srun Lim Song

អត្ថបទសង្ខេប

អេកូឡូស៊ី នៃប្រភេទត្រីក្នុងតំបន់ទំនាបបឹងទន្លេសាប រួមមាន: ការរស់នៅ ការបន្តពូជ ការចិញ្ចឹមជីវិត ការធំធាត់ និងបាត់បង់បរិមាណត្រី ត្រូវបានគេយកមកប្រើប្រាស់ ដើម្បីធ្វើការសិក្សាស្រាវជ្រាវទៅលើតុល្យភាពនៃប្រភេទមច្ឆាជាតិផ្សេងៗ ដែលគេប្រទះឃើញនៅតាមទីកន្លែងស្រាវជ្រាវនានានៃបឹងទន្លេសាប។ ពពួកមច្ឆាជាតិចម្រុះ នៅតាមតំបន់ទំនាបលិចទឹកមានច្រើនប្រភេទ អាស្រ័យទៅនឹងទីជម្រកសមស្របនៅទីកន្លែងផ្សេងៗគ្នា ហើយមានប្រភេទមច្ឆាជាតិជាង ៣០ប្រភេទ ផ្សេងទៀតជាធម្មតារស់នៅតាមកន្លែងដែលបានសិក្សាស្រាវជ្រាវ។ ពាក់ព័ន្ធទៅនឹងភាពសម្បូរណ៍បែបនៃប្រភេទត្រីទាំងនេះ គឺមានការប្រែប្រួលទៅតាមធម្មជាតិ ប៉ុន្តែភាគច្រើនបណ្តាលមកពីឥទ្ធិពលរបស់មនុស្ស ជាពិសេសនៅពេលដែលប្រើប្រាស់បច្ចេកទេសនេសាទថ្មីៗ ត្រូវបានយកមកអនុវត្តជាទូទៅនៅទូទាំងប្រទេសកម្ពុជា ដូចជាការនេសាទដោយប្រើឧបករណ៍ឆក់ និងការនេសាទដោយឧបករណ៍ស្បៃមុង ក្រឡាល្អិតជាដើម។ ទង្វើទាំងនេះបានជះឥទ្ធិពលយ៉ាងធ្ងន់ធ្ងរទៅលើពពួកវារីសត្វនៅក្នុងដែនទឹកធម្មជាតិ។

Abstract

The ecology of Tonle Sap floodplain fish, their distribution, reproduction, feeding, growth and mortality are used to examine the community structures, the balance of different types of fish species, found at the study sites of Tonle Sap Lake. Floodplain communities are invariably diverse following the wide range of habitats available and more than 30 species are common in each of the study sites. The relative abundance of these species fluctuate naturally, but are also under human influence, particularly when new fishing methods are introduced and used such as electro-fishing and small mesh size (mosquito net) fishing gears which have recently spread widely in Cambodia. This type of practice has seriously affected the living aquatic animals in the water bodies.

Introduction

There are about 500 fish species found in Cambodian territory among 1200 in Mekong River, but about 280 fish species found in Tonle Sap Lake (Thuok N., 1998). However, more than 30 different fish species are commonly represented in the fish catches of the project sites. The populations are broadly similar and all contain several representatives of the (mostly herbi/omnivorous) Cyprinids, and the (mostly carnivorous) Channid, Silurid and Anabantid families common throughout freshwaters bodies. In terms of the number of species, the Cyprinids and catfish dominate the catches. The actual weights of different types of fish caught, however, are highly variable. Each species has been roughly classified either from simple observations or literature sources in terms of its migration habits, size, and feeding. The percentage of fish in each ecological category is examined in a number of the following sections.

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Fish distribution and migrations

The distribution and migration of Tonle Sap floodplain fish species depend largely on their abilities to tolerate the extreme conditions, which develop on the floodplain as it is very shallow in dry season, these may include low oxygen and pH levels and high temperatures. Differences in the spatial distributions of floodplain fishes are most pronounced in the dry season, when two broad classes may be distinguished (Welcome 1985):

- Whitefish: 'rheophilic' flowing-water fishes, intolerant of severe dry season conditions, emigrate from the floodplain, back to the main river.
- Blackfish: 'Limnophilic' still-water fishes, adapted to survive deoxygenated conditions, remain in the standing waters of floodplain, or may burrow into the mud in very dry years.

Figure 1. Dai fishing in Tonle Sap.

The term Blackfish and Whitefish are very common used with fishermen in Cambodia.
Whitefish thus migrate onto the floodplain every year to take advantage of the good feeding available, but must return to the river due to their intolerance of the deoxygenated waters in the standing pools of the dry season .

These species usually included Cyprinids *(Cirrhinus microlepis, Hampala macrolepidota, Barbodes altus, Leptobarbus hoeveni, Osteochilus melanopleura, Morulius chrysophekadion),* Pangasiids *(Pangasius larnaudiei, P. pangasius, Pangasianodon hypophthalmus)*, Silurids *(Wallago attu, Micronema apogon)* and Notopterids *(Notopterus chitala, N. notopterus)*. Fish leave the drying floodplain in an ordered sequence of species with the least tolerant and often the larger or older fish emigrating first. In large river systems, many fish also migrate to optimal breeding habitats, usually upstream of the main floodplains so that developing fry drift downstream towards the best nursery areas, particularly, in the flooded forest around the Tonle Sap Lake and along the sides Mekong River.

Blackfish, in contrast, may spend their whole lives in the standing waters of the floodplain and are particularly common in Asian inland waters. These species include Clariid *(Clarias batrachus, C. macrocephalus),* Channids *(Channa micropeltes,* C. *striata),* Bagrid *(Mystus nemurus, M. mysticetus*), Belontids *(Trichogaster microlepis, T. pectoralis*) and Anabatid (*Anabas testudineus).* All such blackfish have some form of air breathing adaptation, and young *Channa punctatus* for example may surface to breathe up to 1900 times per day. The blackfish most commonly have anatomical developments of their gills or branchial chamber. The blackfish species have all developed some form of diverticula of the branchial cavity. This is least developed in Channids, which have only a simple vascularised cavity; Anabantids have developed 'labyrinth' organs from their first gill arch; Clariids have two 'arborescent' organs extending from the 2nd and 4th gill arches; and Heteropneustids have extended the branchial cavity along the body to create a functional air sac. Such fish can survive in totally anoxic water, but many , including the Clariids and Heteropneustids, are still vulnerable to desiccation. Channid fish, however, can even survive short periods of total drought by cocooning themselves in the drying mud in a layer of hard slime with only a thin air passage to the surface to maintain oxygen exchange (see reviews in Lowe-McConnell, 1975 and Welcomme, 1985).

At the project sites, the majority of fish species are non-air-breathing whitefish. The greatest contributions to the total weight of the catch, however, are made of blackfish species such as Channids, Clariids and gouramis (Table 13). This may suggest either that blackfish species are particularly well suited to these floodplain habitats, or that whitefish species have been overexploited, possibly due to their greater vulnerability to the many filtering gears which intercept their movements.

Figure 2. Fish production in Tonle Sap.

Fish reproduction

Maturation

Maturation in tropical floodplain fish is generally very rapid as an adaptation to the uncertain survival rates in such an environment. Most small species are ready to breed at the onset of the first rainy season following their birth, though larger species may delay maturation until their second, third or even fourth years. *Anabas testudineus, Clarias batrachus, Colisa fasciatus, Helostoma temmincki, Heteropneustes tassilis,* and *Trichogaster pectoralis* have thus all been reported to mature by the end of their first year, ready for spawning at the beginning of the new flood (various references in FAP 17, 1993 and Lowe-McConnell, 1975). *Channa striatus* snakeheads have been observed with maturing ovaries in Cambodian wetland areas in April and May at sizes less than 25 cm, thought to correspond to ages less then one year old. Elsewhere *Channa micropeltes* has been reported to mature at between one and two years of age.

Reproductive strategies

Reproductive methodologies can be broadly divided as follows (from a classification by Balon, 1981):

Non-guarders :	-Open substratum spawners	Catla, Puntius, Cirrhinus
(Total spawners)	-Brood hiders	
Guarders :	-Open substratum spawners	Channa, Anabas
(Partial spawners)	-Nest spawners	Notopterus, Clarias, Trichogaster
Bearers :	-External bearers	
	-Internal bearers	

Examples are given of fish species from Asian floodplains following the first two breeding types. Both free spawners and guarders are common, but few incubating or bearing fish such as the mouth brooding African cichlids are found. The non-guarders or total spawners include whitefish such as the Cyprinids *(Henicorhynchus lobatus, Cirrhinus jullieni)*. The larger species produce many small eggs up to several hundred thousand or millions in a synchronised season, usually at the start of the flood, to place the fry in regions of good aeration, abundant food and vegetation cover, and low predation. Hatching times for such fish are usually short, down to as little as one day in open substratum spawners such as *Cirrhinus jullieni, Hypsibarbus pierrei*, and the fry of these fish are able to utilize the extended floodplain habitat for the longest possible period. The main danger of a total spawning strategy is the chance of spawning being triggered by false stimuli such as a temporary raise in water levels, only to leave the whole cohort stranded before the full monsoon arrives. Recruitment variability may thus be expected to be higher in such fish, especially if flood regimes are modified by river regulation or habitat degradation.

The guarders, in contrast, migrate only laterally within

the local floodplain area and produce fewer eggs (a few hundreds or thousands). They may, however, breed several times per year and increase their progeny's survival by parental care. Guarders are often blackfish which spawn on the floodplain in poor water Quality, but place their eggs or nests at the water surface to take advantage of the higher oxygen levels. Some Anabatids including *Anabas testudineus* lay floating eggs indiscriminately in weedy margins while others such as *Trichogaster pectoralis* and the larger *Osphronemus goramy* build a foaming nest of air bubbles held together by a hardened secretion into which the eggs are laid. Spreading the broods throughout an extended season may be advantageous in the highly variable floodplain environment by ensuring that at least one of the broods is able to survive. Comparing the strategies suggests that floodplain fish catches should be composed of fairly constant catches of blackfish, and variable, occasionally great catches of whitefish, when their spawning is successful.

Trophic relationships

The seasonality of feeding in tropical fish is determined largely by habitat availability, linked to the rise and fall in water levels. Both food availability and population densities improve during the flood, and become restrictive at low water. High water feeding enables fish to build sufficient reservoirs of body fat to survive the dry season and to develop gonadal material in preparation for imminent breeding. During the dry season, many fish are seen to lose condition (weight) of up to 10%, but certain predatory fish may be able to continue feeding throughout the dry season if their prey species are stranded alongside them.

The food resources of river floodplain ecosystems are diverse and can be divided roughly into those originating from within the system and those from outside (as listed by Welcome, 1985) :

Autochthonous food resources

Plankton community:	phytoplankton; zooplankton; drift organisms.
Benthic community:	mud and associated microorganisms; coarse detritus, decomposing animal and vegetable remains; insects and small crustacean.
Plant community:	including filamentous algae and submersed, floating or emergent higher vegetation.
Epilithic-Epiphytic community:	epiphytic and epilithic algae; associated microorganisms, insects, crustacea etc.; this category includes the root flora and fauna of floating vegetation as well as the detrital aggregate, the coating of detritus, bacteria and algae found on submerged parts of plants and rocks.
Neuston community:	insects and larvae living at the air/ water interface.
Fish:	including eggs, larvae and juveniles.
Other vertebrates:	amphibian, reptiles, birds, small aquatic mammals.

Allochthonous food resources

Vegetable matter:	leaves, roots, flowers, fruit and seeds of plants growing near Or overhanging the water course.
Animal matter:	insects, arachnids, worms etc falling or washed into the water from the terrestrial environment.

The higher plants are the chief primary producers in floodplain rivers, and the most important food chain derives from the decay of this dried out, and then re-flooded vegetation by micro-organisms, detritus feeding inverts and fish and then to various levels of piscivorous fish. Four of the above categories thus emerge as particularly important in floodplain systems: the detritus communities of the benthos, the allochthonous materials, particularly in swamp forests, and predation. The full use of foods from the lowest trophic levels, in the first three categories gives floodplains their characteristically high production rates. The importance of predation rises as one moves from the upper head streams, to the lower potamon reaches of rivers with their floodplains, and also increases as the dry season progresses, as food resources for the other trophic levels become scarce.

Most species are specialized to take advantage of a limited range of these foods, but are also able to switch feeding preferences as the season progresses to take advantage of food sources which become abundant for limited times. Many species thus have overlapping niches largely in response to the variability in the environment, and there is little competitive exclusion among the fish communities.

Similar numbers of each trophic category are found at each of the project sites. More than 40% of both the number of species and the catch weights are comprised of carnivorous fishes including large Channid snakeheads and Siluroid catfishes and smaller Notopterids and perches. This dominance of carnivorous fish is characteristic of SE Asian river systems (Lowe-McConnell, 1987). The remaining fish have mostly been classified as either herbivores or omnivores and include several Cyprinids and Anabantid perches. As noted above, the food preferences of many such fish are flexible, and few thorough studies are available to enable rigorous separation of these and the other groups. Overall, there do not appear to be large differences in the trophic composition of the three communities and the multi-species nature of these systems may be seen to be in response to the diversity of foods available in the Tonle Sap Lake.

Fish growth

The growth of Tonle Sap floodplain fish may be characterised as fast and seasonal. Growth broadly follows the feeding pattern described above, with the fastest growth observed in the high water season. Many large species grow particularly fast in their first season, possibly as an adaptation to avoid the intense predation of the floodplain by rapidly exceeding edible size before the shelter of the floating vegetation disappears in the dry season. An alternative strategy may be adopted by smaller species, which remain vulnerable to predators all their lives, but mature and breed as early as possible.

Year to year variations in growth can also be pronounced in these environments, largely depending on the intensity and duration of flooding. In the Mekong River, fish have been shown to achieve smaller in their normal sizes in poor year, particularly in 2003 water level was much lower than previous year, resulting in reproduction failures.

Growth rates have been estimated for the key species at the study sites from the length frequency data collected between April and December, 2003. Maximum fish sizes are highly variable from less than their normal sizes. Nearly all fish, however, including the largest snakeheads, grow towards their asymptotic lengths very fast, at around 45-50% per year. The slow growing species are usually best exploited by delaying or reducing exploitation below that of

the other fish until they have grown to a reasonable size.

Mortality

The causes of mortality may be grouped in two interrelated classes:

- Density dependent (where density may relate to the species itself, or those of its competitors or predators); and
- Density independent (related to physical/chemical changes in the environment).

Density dependent factors include intraspecific and interspecific competition for food and/or space. Competition for resources exists whenever populations breed beyond the carrying capacity of their environment. Since this capacity is constantly varying in these habitats, competition must occasionally be indirectly raised, especially as water levels are falling. The more important contribution to density dependent mortality is that of predation, particularly with the high levels of carnivorous fish observed. Mortality due to disease also usually increases with density as the cramped conditions favor the transmission of parasites and other pathogens. A condition known as epizootic ulcerative syndrome (EUS) has swept through all three of the countries over the past decade, with blackfish being notably vulnerable to infection. The highest prevalence has been observed during the dry season in Tonle Sap lake and other water bodies in Cambodia.

In many floodplains, a major cause of density independent natural mortality is stranding. This may result in the loss of four times the fish actually caught (Bonetto *et al.,* 1969 in Welcomme, 1985) but has not been frequently observed at any of the project sites, suggesting that they are relatively heavily exploited. Spectacular fish kills may also be caused by sudden deoxygenation in eutrophic or polluted rivers especially in high summer temperatures, but again are not common at the project sites. Excessively high or sudden flooding can also raise mortalities as fish, eggs or fry get swept out of the river system to unsuitable habitats.

From the combination of the most important factors, predation, disease, seasonal habitat deterioration, and fishing, the greatest losses of fish generally occur during the drawdown and low water phases (Welcomme 1985). This pattern implies that an excess of fish biomass is normally produced during the flood, which will always enable the maximum possible dry season survival into the next year. Much of this biomass can clearly be removed as yield to the fishery, without harming the potential of the stock. The exact amount that can be taken remains a crucial question. The relationship between stock sizes and recruitment are obscure in even the best study fisheries, and no information is available on the likely forms for floodplain fish.

The implication of high mortality rates is that few fish survive to ages greater than one, two or perhaps three years old. The relatively young structure of floodplain river communities confirms the dynamic, opportunistic and rapidly circulating nature of these ecosystems.

Conclusion

There are more than 500 fish species has been found in Cambodian territory among 1200 in Mekong River, but over 250 fish species found in Tonle Sap Lake. However, more than 30 different fish species are commonly represented in the fish catches of the project sites during the study period. The relative abundances of these species fluctuate naturally, but are also under human influence.

The distribution and migration of Tonle Sap floodplain fish and their feeding patterns determine their vulnerability to the various types of fishing gears used in different parts of the floodplain as the season progresses. Floodplain habitats experience a characteristic annual sequence of events in which the biomass and production of most fish foods increases during inundation to give the main feeding season in the flood where fish grow well in such nature. Fish populations are often adapted to this cycle by spawning at the beginning of the flood, particularly in June/July and placing their progeny on the floodplain at a time of plenty. The uncertainty over future water levels and the large number of predators then gives strong selection pressure for rapid growth and early development.

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OU REANG OV: A NEW SOIL GROUP FOR THE CAMBODIAN AGRONOMIC SOIL CLASSIFICATION

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អត្ថបទសង្ខេប

ដីបាសាល់គ្របដណ្តប់លើតំបន់សំខាន់ៗ នៃប្រទេសកម្ពុជាភាគខាងកើត និងស្ថិតនៅក្នុងតំបន់តូចៗដទៃឯទៀត នៅភាគខាងជើង ភាគឦសាន និងភាគពាយព្យនៃប្រទេស។ ដីបាសាល់ ទំនងជាផ្តល់លក្ខណៈល្អ ក្នុងការអភិវឌ្ឍន៍ដំណាំកសិកម្មខ្ពង់រាប ក៏ប៉ុន្តែលក្ខណៈធម្មជាតិ និងលក្ខណៈសម្បត្តិនៃដីប្រភេទនេះពុំត្រូវបានគេស្គាល់ច្បាស់ឡើយ។ ក្នុងការសិក្សានៅក្នុងស្រុកអូររាំងឪ ខេត្តកំពង់ចាម ដីល្បាយឥដ្ឋលាយត្រួស ដែលមិនធ្លាប់បានធ្វើការពិពណ៌នាពីពេលមុនមកនោះ ត្រូវបានជួបប្រទះជាទូទៅ។ នៅក្នុងស្រុកអូររាំងឪ ដីនេះមានប្រហែលដល់ទៅ ១៣ ភាគរយ នៃដីបាសាល់។ តាមលក្ខណៈរូបសាស្ត្រ ដីនេះមានលក្ខណៈខុសគ្នាយ៉ាងច្បាស់ពីដីដាំស្រូវ ដែលបានពិពណ៌នាសម្រាប់ដីបាសាល់ (ក្រុមដីឡាបានស្បែក និងកំពង់ស្បែម) និងកើតមានឡើងនៅលើកូនភ្នំ និងខ្ពង់រាបបាសាល់។ ក្រុមដីអូររាំងឪ ត្រូវបានស្នើឱ្យទៅជាក្រុមដីថ្មីមួយទៀតនៃចំណាត់ថ្នាក់ដីកសិកម្មកម្ពុជា។ ក្រុមដីអូររាំងឪនេះមានលក្ខណៈច្រោះទឹកខ្លាំង និងមិនសមស្របសម្រាប់ដំណាំស្រូវឡើយ។ តាមការពិតវត្តមាននៃត្រួសនៅក្នុងដី ធ្វើឱ្យដំណាំរងាប់ទទួលរងនូវភាពរាំងស្ងួត។ ក្រៅអំពីភាពជូរនៃដីស្រទាប់ក្រោម ក្នុងប្រូហ្វីលខ្លះ លក្ខណៈសម្បត្តិគីមីផ្សេងៗទៀតនៃដី មានភាពអំណោយផលល្អ។ ការពិតនៅលើដីអូររាំងឪនេះ សារធាតុផូស្វ័រ ដែលអាចចំរាញ់ចេញបានមានកំរិតខ្ពស់ជាទូទៅ។ ដីឥដ្ឋកៅឡាំង (Kaolinite) និងថ្មក្រាស្យ (Quartz) ជាសារធាតុរ៉ែ ដែលមានច្រើនលើសលប់ជាងគេនៅក្នុងដីអូររាំងឪនេះ ទោះបីជាវាយនភាពនៃដី បង្ហាញឱ្យឃើញថាមានសារធាតុក្លាស្យយ៉ាងច្រើនស្ថិតក្នុងប្រភាគជាទំហំដីឥដ្ឋ និងល្បាប់ម៉ដ្ឋក៏ដោយ។ សារធាតុខនិជនៃដីឥដ្ឋ ស្មិចថាយ (Smectite) ត្រូវបានជួបប្រទះជាញឹកញាប់ ទោះបីជាដីនេះមិនបង្ហាញឱ្យឃើញនូវការប្រេះក្រហែងនៅលើផ្ទៃដីនៅពេលដែលវាស្ងួតក៏ដោយ។ ទោះបីជាវាកើតមាននៅលើទីចំណោតក្តី ដីអូររាំងឪនេះ មានការធន់ទៅនឹងការហូរច្រោះជាបង្អួរដែរ ហើយជាទូទៅវាមានសក្តានុពលពីមធ្យមទៅល្អ សម្រាប់ការដាំដំណាំ ប្រសិនបើដំណាំដែលមានលក្ខណៈធន់ទៅនឹងភាពរាំងស្ងួតត្រូវបានគេជ្រើសរើសសម្រាប់ដាំ។

ពាក្យគន្លឹះ: ដីបាសាល់ ត្រួស សមាសភាពទឹកក្នុងដី សមត្ថភាពនៃដី ។

Abstract

Basaltic terrain occupies significant areas of eastern Cambodia and occurs in pockets elsewhere in the north, north-east and north-west. Basaltic soils are likely to be prominent in the development of upland cropping; however, the nature and properties of these soils are poorly understood. In studies in Ou Reang Ov district of Kampong Cham province, a previously undescribed brown gravelly clay loam soil was found to be prevalent. In Ou Reang Ov district it comprises about 13 % of the basaltic terrain. It is morphologically distinct from the rice soils described for basaltic terrain (Labansiek and Kompong Siem Soil groups) and occurs on the slopes of basaltic hills and plateau. The Ou Reang Ov Soil group is a newly proposed member of the Cambodian Agronomic Soil Classification. The Ou Reang Ov Soil group is well drained and unsuited to padi rice. Indeed the gravel content of the soil makes field crops prone to drought. Apart from sub-soil acidity in some profiles, other soil chemical properties were generally favourable. Indeed the extractable P levels on Ou Reang Ov soil were generally high. Kaolin and quartz were the dominant minerals in Ou Reang Ov soil although the soil texture suggests that much of the quartz is in silt and clay size fractions. Smectite clay minerals were prevalent even though this soil does not exhibit cracking at the surface when dry. Although occurring on slopes, the Ou Reang Ov soil is relatively resistant to erosion. Overall it is considered to have fair to good capability for cropping, if drought tolerant crops are selected.

Keywords: Basalt, gravel, soil water content, land capability.

Introduction

Pleistocene basalt flows are quite extensive in eastern Cambodia (Workman 1972). Similar aged basalt flows occur in southern Laos and the central highlands of Vietnam (D'haeze *et al.* 2001), and to a minor extent in Northeast Thailand (Tawornpruek 2005). In Cambodia, the greatest area of basaltic terrain occurs as a series of lava sheets with elevations up to about 300 m above sea level in Kampong Cham province, extending into the south-east of Kampong Thom province and north to Kratie (SCW 2006). Additional large areas of basalt occur in southeast Mondulkiri, and in eastern Ratanakiri, bordering Vietnam. Smaller but significant occurrences of basalt are found in the vicinity of Kulen mountains, north-east Kampong Thom province and in Battambang province.

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Basaltic soils suitable for rice were assigned to two Soil groups in the Cambodian Agronomic Soil Classification (CASC) (White et al. 1997). The Kompong Siem soil is distinguished by its black to very dark grey colour, and cracking clays. It is a significant rice growing soil in Kampong Cham and Kampong Thom where is occurs *in situ* on low elevation sheets of lava flows, and on the alluvial/ colluvial outwash of these sheets. The Labansiek soil is only a minor padi rice growing soil because its higher elevation on the basaltic plateau and free draining characteristics make it less favourable for padi rice: it is used for upland rice. However, at present upland rice is no longer grown extensively on Labansiek soil because profits are much less than that obtained from growing field crops such as maize, mungbean, soybean, peanut and sesame.

Basaltic terrain is common in other tropical regions, including those with a similar monsoonal savannah climate to that which occurs in much of Cambodia (e.g. Isbell et al. 1976, 1977- northern Australia; D'haeze *et al.* 2001- central highlands of Vietnam). The basaltic terrain of the central highlands of Vietnam has been the focus of significant agricultural development in the past 20 years (D'haeze *et al.* 2001) where a major coffee production centre has been developed in Dac Lac province. Coffee is grown on a range of basaltic soils in this province, but is most suited to the well drained Rhodic Ferralsols which occur on the crests of the basaltic plateau, and not suited to the poorly drained and shallow Phaeozem and Vertisols. In Cambodia, deeply weathered red soils on the crests of the basaltic plateau were selected for rubber plantations during the French colonial administration. About 43,000 ha of these soils support rubber in Kampong Cham and there is a potential for a threefold expansion of the area under rubber (FAO 1999; OPCV 2002; Statistics Office MAFF 2004). Because of the high potential agricultural productivity of the soils developed on basalt, their distribution and properties warrant more thorough research in Cambodia. The basaltic soils may have considerable potential for the development of a productive, diversified and sustainable upland agriculture, especially in eastern Cambodia.

This paper describes a new Soil group of upland soils, the Ou Reang Ov Soil group, proposed by Seng *et al.* (2005) for inclusion into the CASC (White *et al.* 2000). Only the rice soils of Cambodia have been described in detail (White et al. 1997). The naming and identification of the Rice Soil groups has become familiar to agronomists, extension officers and farmers in Cambodia due to their common usage and the many training programmes conducted on their identification and properties (Heer et al. 1999). However, the Rice Soil Manual does not describe all the soils of Cambodia and neither was it intended to do so (White et al. 1997). The key for identification of rice soils allows for the future identification of presently undefined and unclassified soils. Most of the non-rice soils of Cambodia are likely to fall into this category. Increased emphasis on crop diversification and upland farming has created a need for more detailed investigation of the soils in these upland areas. It is important to note that for upland soils, profile descriptions will need to be deeper than the 20 cm generally used for rice soils, because of the greater root depth of crops on upland soils (White et al. 1997), and their greater reliance on sub-soil stored water and nutrients.

The purpose of this paper is to assist agronomists, extension officers and farmers to recognise a new upland soil, Ou Reang Ov Soil group, and to outline its main limiting factors, soil management requirements, and potential for land use. It outlines the appearance, properties and management of the Ou Reang Ov Soil group. A more detailed explanation of its taxonomy, pedogenesis and soil chemical properties can be found in Hin *et al.* (2005) and a formal proposal for the inclusion of the Ou Reang Ov Soil group in CASC is reported in Seng *et al.* (2005).

Materials and methods

Location

The field investigation was conducted in the district of Ou Reang Ou, east of the Mekong River in the province of Kampong Cham, about 165 km from Phnom Penh.

Climate

Cambodia has a monsoonal climate, which is characterised by distinct wet and dry seasons. The dry season starts in November, with the early wet season beginning in April and the main wet season beginning in July. There are no rainfall records yet for Ou Reang Ov district, however, the average annual rainfall ranges between 1500 and 1750 mm (Nesbitt 1997) whereas SCW (2006) suggests rainfall is closer to 1750 mm. At Chup in Tbong Khmum district, the closest rainfall monitoring station to Ou Reang Ov district, average monthly rainfall for the last 10 years was fairly consistent between May and October at 240-270 mm/ month (Fig. 1). Daily temperatures range from 21 to 35 ^{o}C. Highest maximum temperatures are reached in April to May with the coolest time of the year being from October to January.

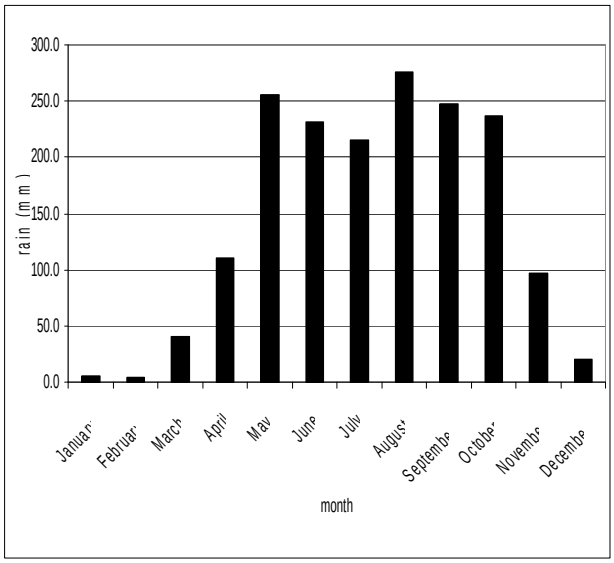

Figure 1. Average monthly rainfall for Chup station, Tbong Khmum District, Kampong Cham Province (10 years of data) (Vance *et al.* 2004). Mean annual rainfall for Chup is 1740 mm.

Geology

The study area comprises uplands of mid-Pleistocene basaltic flows in the northern half of the district, surrounded by associated lowland paddy soils of old and recent alluvium. Ou Reang Ov district is on the southern margin of the basaltic flows in eastern Cambodia (Workman 1972; SCW 2006). The uplands rise to 80-100 m above sea level in Ou Reang Ov, but are higher in other parts of Kampong Cham (Ovens 2005).

Land use

The uplands of Ou Reang Ov district are currently dominated by rubber plantation, the lowlands by mixed land use for paddy rice and non-rice crops (Department of Agricultural Extension (DAE) 2003). Rice is produced in the wet and dry seasons. Groundwater seepage water is used in

places for irrigation, supporting mostly early and main wet season rice with supplementary irrigation, plus a limited amount of vegetable and fruit tree production all year round (Ovens 2005). Field crops produced in the district are peanut, soybeans, sesame, maize, mungbean, chilli and cassava (DAE 2003). These are grown mainly in the wet season in the upland areas not used for rubber plantations. Vegetable crops are also produced in the district where irrigation is possible, and some lowlands that retain significant stored moisture after rice harvesting, are used for watermelon and cucumber production in the dry season.

Method of soil-landscape survey

Detailed soil profile descriptions were completed on four soil pits, in areas of the landscape which were deemed to represent the Ou Reang Ov Soil group. Additional less detailed soil observations were made in the district. In Ou Reang Ov district, the following resources were used to guide soil sampling location: rice soils map for the district (Oberthur *et al.* 2000); a geology map (supplied by Mekong River Commission -MRC); digital elevation model (MRC); US Army Corp topography maps (1:50,000 1967) and digital ortho-rectified aerial photographs (Department of Geography 1:50,000 1992). However, locations of soil pits were constrained, being predominantly at locations used for crop trials. Soil classification was completed by detailed profile descriptions using FAO descriptors (FAO-ISRIC 1990).

Soil pits for this soil have been made at the following locations and the full profile description plus soil analysis results are available in the Cambodia Soil Profile database located at CARDI's Soil and Water Sciences Division.

Site code	Easting	Northing
ACIAR0011	556032	1310665
ACIAR0014	560347	1306195
ACIAR0018	563268	1306525
ACIAR0029	555747	1307117

Note: Datum IND60 Zone 48

Soil chemical analyses

At each soil pit, samples of soil were taken from each horizon. These samples were analysed for electrical conductivity (1:1 soil:water) and pH (1:1 soil:water) in the CARDI laboratory. Analyses of soil chemical characteristics were also completed at CSBP laboratory in Western Australia. These analyses included: nitrogen concentrations as ammonium, nitrate, and total nitrogen; concentrations of extractable phosphorus and potassium, sulphur, copper, zinc, manganese, iron and boron; exchangeable calcium, magnesium, sodium, potassium and aluminium; organic carbon and the electrical conductivity, $pH_{(CaCl2)}$ and $pH_{(water)}$ of the soil (Rayment and Higginson 1992). Data from soil chemical analyses were recorded in the Cambodia Soil Profile Database of CARDI.

Results and discussion

Soil-landscape overview

The main influence on soil-landscape pattern in Ou Reang Ov district was the broad basaltic rises that occur in the northern half of the district. The digital elevation model indicates that these rises may be built up of more that one flow which may help explain the occurrence of different soils on the top of the flow versus the steeper side slopes. Rasmussen and Bradford (1977) also concluded that several basalt flows make up the present plateau with the older flows contemporaneous with the Pleistocene alluvial formations in the southern half of the district.

The basalt rises (60- 80 m above sea level) are more or less undulating on top, limiting erosion and allowing for the development of deeply weathered, red, structured clays [Labansiek, non petroferric phase after White et al. (1997)] The distinctive composition of the top basalt flow may be a contributing factor to the development of the deep red clay soils. These soils, occupying about 14 % of Ou Reang Ov district, are favoured for the growth of rubber trees, but would also have significant potential for other agro-forestry enterprises and for annual crops.

The side-slopes of the basalt rises, occupying about 13 % of Ou Reang Ov district, are generally much steeper and dissected, leading to generally shallower soils and rock outcrop or surface stones and boulders. The soils associated with the basalt slopes are generally brown, and may contain significant amounts of ferruginous gravels and rock fragments. There is no suitable group for these soils in the CASC (White et al. 1997), and a new *Ou Reang Ov* Soil group has been proposed (Seng *et al.* 2005). A low-relief finger of the basalt extends out to the north-west of the main basalt area in Ou Reang Ov district, and this has a mixture of Ou Reang Ov and Kompong Siem soils. Small groundwater seepage areas are common near the exposed interfaces of basalt flows or between the basalt flow and underlying ancient alluvium (Ovens 2005).

The lower colluvial slopes and adjoining plain is influenced by the basaltic parent material, and comprises deep, dark, cracking clay soils (Kompong Siem Soil group). These clays may contain basalt floaters in the profiles near to the hills, but floaters become less common with distance from the hills. A broad and seasonally flooded plain to the south and east of the district is dominated by deep Kompong Siem soils, free of rock or ironstone gravel. Collectively the soils mapped as Kompong Siem Soil group occupy about 60 % of Ou Reang Ov district (Hin *et al.* 2005), but were less prevalent in Ponhea Krek district (Hin Sarith, personal communication).

In the south-west of Ou Reang Ov district, the plains are derived from either Recent Mekong River alluvium or from old Pleistocene alluvium. Permanent swamps and associated seasonal swamps are also common between the basalt uplands and the Mekong River in the west of the district.

Typical Soil Profile of the Ou Reang Ov Soil Group

The soil profile below for the site known as ACIAR 0014 in the Soil database is representative of the four soil pits described. The site had a gentle slope. The soil had abundant-common sub-rounded igneous rock gravel although it was not clear if gravels were pedogenic in origin. It has a hard setting surface.

ACIAR0011 was classified as Skeletal Phaeozem (FAO -ISRIC-ISSS, 1998). By contrast, profiles recognised as Kompong Siem Soil group from nearby were classified as Gleyic Phaeozom (Hin *et al.* 2005). A shallower profile (ACIAR0029) was provisionally classified as a Regosol. According to Crocker (1962), this soil would probably be assigned to the Regur Great Soil Group. Hence taxonomically there is some variation in the Ou Reang Ov Soil group. However, Soil groups in CASC are based on similarity in effects on crop production, rather than soil taxonomic features (White *et al.* 1997).

Horizon	Depth (cm)	Description
Ap	0-12	very dark greyish brown (10YR 3/2 moist) clay loam; slightly hard dry consistence; massive structure; many segregations, fine ferruginous rounded reddish brown hard; common roots, fine; moderate permeability; pH 6.53 (1:1 water); EC 0.3 mS/m (1:1); fine, medium porosity, vughs void; clear, smooth boundary.
BC1	12-85	dark brown (10YR 3/3 moist) clay; friable moist consistence; moderate, fine, angular blocky structure; abundant segregations, fine ferruginous irregular yellowish brown hard; few roots, fine; very few coarse fragments sub-rounded stones of basalt; moderate permeability; pH 6.63 (1:1 water); EC 0.3 mS/m (1:1); fine, vughs void; diffuse, wavy boundary.
BC2	85-120+	brown (10YR 4/3 moist) clay; fine distinct light brown (7.5YR 6/4 moist) mottles; friable moist consistence; weak, fine, angular blocky structure; abundant segregations, medium ferruginous irregular brown hard; no roots; moderate permeability; pH 6.87 (1:1 water); EC 0.3 mS/m (1:1); fine, vughs void.

Soil chemical properties

Soil pH was generally moderately acid in the surface horizon but decreased on some profiles to strongly acid at depth (> 18-25 cm) (Table 1). Among the profiles there was some variation in sub-soil pH. Only one of the profiles (Site 11) had significant Al saturation level, about 40 % below 45 cm (Table 3). Ou Reang Ov soil contained low to moderate (> 1.5 %) organic C levels and total N was also very low (Tables 1 and 2).

Table 1. Organic carbon and pH of soils of Ou Reang Ov Soil group

Site	Depth (cm)	Organic carbon (%)	pH $CaCl_2$	pH H_2O
11	0-18	1.54	6.1	7.1
	18-45	0.83	4.7	5.7
	45-88	0.53	4.4	5.5
	88-120	0.37	4.3	5.4
14	0-12	1.79	5.7	6.7
	12-85	0.63	5.5	6.6
	85-120	0.64	5.4	6.5
29	0-10	1.58	5.5	6.5
	10-25	0.97	5.2	6.1
	25-60	0.93	4.7	5.7
18	0-10	1.1	5.5	6.6
	10-30	0.82	5.8	6.6
	30-75	0.56	4.5	5.4
	75-120	0.37	4.6	5.6

Table 2. Exchangeable cations, effective cation exchange capacity (ECEC) and Al saturation in soils of Ou Reang Ov Soil group

Site	Depth (cm)	Ca	Mg	Na	K	Al	ECEC	Al saturation (%)
		(cmol/kg)						
11	0-18	7.5	3.16	0.03	1.74	0	12.4	0
	18-45	2.3	2.32	0.02	0.4	0.36	5.4	7
	45-88	0.69	1.58	0.03	0.84	1.82	5.0	37
	88-120	0.62	1.43	0.04	0.78	2.22	5.1	44
14	0-12	13.0	5.37	0.05	1	0	19.4	0
	12-85	10.5	9.67	0.07	0.44	0	20.7	0
	85-120	10.8	9.1	0.08	0.5	0.03	20.5	0
18	0-10	6.8	2.35	0.01	0.62	0	9.8	0
	10-30	6.13	2.47	0.02	0.27	0	8.9	0
	30-75	3.16	2.33	0.02	0.4	0.55	6.5	9
	75-120	3.73	2.2	0.03	1.01	0.45	7.4	6
29	0-10	9.34	5.04	0.06	0.42	0	14.9	0
	10-25	8.4	5.51	0.1	0.28	0.01	14.3	0
	25-60	7.74	7.59	0.2	0.34	0.08	16.0	1

Exchangeable Ca levels in the Ou Reang Ov soils were moderate to high except in sub-soil layers of the most acidic profile (Table 3). Exchangeable Mg was uniformly high. Unlike in Kompong Siem soils, there was negligible exchangeable Na throughout. Exchangeable K levels were generally moderate to high.

Extractable P levels were generally high (Table 3). Extractable S was generally low but there were moderate levels in sub-soils of two profiles (Sites 11 and 18). Ou Reang Ov soils contained moderate levels of the extractable micronutrients, B, Cu, Zn and Mn (Table 3).

Table 3. Extractable nutrient levels in soils of Ou Reang Ov Soil group

Site	Depth	Nitrogen			Bicarb. P	KCl-S	DTPA Cu	DTPA Zn	DTPA Mn	Hot $CaCl_2$ B
		NO_3	NH_4^+	Total N						
	(cm)	(mg/kg)	(mg/kg)	(%)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
11	0-18	1.0	7.0	0.12	132	4.6	1.25	5.18	40.0	0.7
	18-45	2.0	4.0	0.07	96	3.6	0.94	1.47	20.1	0.4
	45-88	4.0	6.0	0.07	54	9.4	0.57	1.14	14.2	0.4
	88-120	7.0	5.0	0.07	23	13.8	0.43	1.03	8.31	0.4
14	0-12	7.0	7.0	0.12	191	3.5	2.21	4.2	26.2	0.6
	12-85	2.0	5.0	0.07	27	5.2	2.06	0.69	15.4	0.4
	85-120	2.0	4.0	0.07	22	5.5	2.14	0.73	13.0	0.4
18	0-10	5.0	10.0	0.08	129	2.5	1.52	3.99	33.6	0.5
	10-30	7.0	1.4	0.08	106	1.3	1.36	1.47	22.8	0.5
	30-75	13.0	<1	0.07	50	13.5	1.12	0.74	29.0	0.4
	75-120	11.0	<1	0.05	37	7.9	1.59	1.12	62.5	0.4
29	0-10	6.0	16.0	0.14	26	3.3	2.3	3.36	77.9	0.3
	10-25	4.0	31.0	0.1	21	5	2.37	0.96	50.7	0.4
	25-60	3.0	16.0	0.1	13	6.5	2.47	0.92	60.8	0.3

Mineralogy

The one profile of Ou Reang Ov analysed (Table 4) contained significant smectite clays, indeed about the same content as Kompong Siem Soil group. Site 14 contained only 5 % Fe oxides. The dominant minerals in the Ou Reang Ov profile were kaolinite and quartz. Traces of ilmenite were found in Ou Reang Ov soils. The mineralogy of the Ou Reang Ov Soil group indicates that it is intermediate between that of the Labansiek and Kompong Siem Soil groups.

Table 4. Mineralogy of soil profiles from X-ray diffraction of powder preparations of horizon samples from one profile of Ou Reang Ov Soil group

Site	Depth (cm)	Smectite	Kaolinite	Quartz	Fe-oxide	Feldspar	Ilmenite
				(%)			
14	0-12	10	15	55	5		5
	12-85	15	25	55	5		traces
	85-120	15	30	50	5		traces

Keys to identify the soil

Below is a keys to identify Ou Reang Ov soil group using the framework of CASC.

1. The soil is flooded for at least 3 months or longer for at least 4 out of every 5 years by river or lake water?	**No**
↓	
2. The soil occurs on the sides of hills or mountains?	**No**
↓	
3. The soil occurs on an area of undulating topography?	**Yes**
↓	
4. The soil has loamy or clayey topsoil and loamy or clayey subsoil?	**Yes**
↓	
5. Basalt rocks, stones, or boulders can be seen on the soil surface or in the soil profile or occur in the general area and are known to be associated with this soil?	**Yes**
↓	
6. The soil color is dark gray to black?	**No**
↓	
7. The color of the surface soil is red to brown and the soil has a crumb structure?	**No**
↓	
8. The color of the surface soil is brown to dark brown, and the soil has many fine brown or red hard nodules/gravels throughout the profile?	**Yes** (Ou Reang Ov Soil Group).

General discussion

The Ou Reang Ov Soil Group is a dark brown to very dark brown colored soil with a high proportion of gravel derived from weathering of basalt and commonly found on mid to upper slopes of basalt plateau. There is no suitable group for these soils in the Rice Soils of Cambodia (White *et al*. 1997), and the new *Ou Reang Ov* Soil Group has been proposed (Seng *et al.* 2005). The elevation of Ou Reang Ov Soil group in the basaltic landscape is above where the Kompong Siem soil is found (Fig. 2), and below the Labansiek soil. Currently, only the gravelly phase of this soil is proposed. The Ou Reang Ov soil occurs in similar locations and generally in close proximity to Labansiek and Kompong Siem Soil groups in the basaltic landscapes of Kampong Thom, Kampong Cham and Kratie provinces. All three soils occur in eastern Kampong Thom province (they were observed as far west as Santuk district), across much of Kampong Cham province (except where the Mekong River and its recent and ancient floodplain occurs in the province) and into parts of Kratie province. Ou Reang Ov soils are likely to be common in these provinces but the extent of it needs confirmation by more extensive field observations. Basaltic geology is also extensive in Ratanakiri and Mondolkiri provinces (Workman 1972) and significant patches occur in Preah Vihear, and Battambang provinces, but the soils associated with these occurrences of basalt have not been determined.

Figure 2. A schematic representation of the topographic relationships between Labansiek, Ou Reang Ov and Kompong Siem Soil groups.

The basaltic upland is built up of more that one flow (with possible differences in chemical composition) (Rasmussen and Bradford 1977) which may contribute to the occurrence of different soils on the top of the uplands versus the steeper side slopes and lower slopes. However, the relationship between rock composition in basaltic lava flows and soil development has not been tested.

The Ou Reang Ov Soil group profile is moderately deep (usually more than 1 metre) and contains abundant gravel. The surface horizon is 12 to 18 cm deep, dark brown to very dark brown, clayey or loamy texture, with common fine gravel. The surface is generally hard when dry. The subsurface layers are dark brown to dark red, extend generally to 120 cm depth or more, have clay to loamy texture, and are characterised by abundant, medium to coarse size gravel (Fig. 3).

Figure 3. Typical profile for Ou Reang Ov Soil group in Ou Reang Ov district, Kampong Cham province. Note the abundance of ferruginous gravel from about 15 cm depth and below, and the basalt rock at 90 cm depth.

Color in the surface can vary from dark grey and very dark brown to dark brown and dark red. Sub-soil is generally dark brown but can vary to reddish brown. Depth of the soil is sometimes less than 60 cm and sits on top of weathered basalt rock. Gravel (mostly ferruginous in composition but varying to iron-manganese gravels) is a distinctive characteristic of the Ou Reang Ov Soil group. The surface has variable amounts of fine gravel (from none to many), but with depth extending to 90 or greater than 120 cm, gravel becomes medium to coarse in size and abundant. The profile shows very little mottling and does not form cracks. A few coarse fragments of basalt are sometimes present in the soil.

The Ou Reang Ov soils occur in association with the Labansiek and the Kompong Siem soils and may be confused with these soil groups. The Labansiek grades into the Ou Reang Ov soil and then the Ou Reang Ov grades into the Kompong Siem soil with the progression from the top of the basaltic hills to the valley floors. In areas where the soils grade into each other, it may be difficult to assign the soils to a Soil group, however, the following guidelines apply.

Ou Reang Ov Soil group is less reddish in colour than the Labansiek soil especially at the surface. It has medium sized blocky peds compared to the crumb[1] peds of Labansiek. There is more gravel in Ou Reang Ov soil than Labansiek soil. When using the CASC, the Ou Reang Ov Soil Group does not key to Labansiek Soil group due to the dark brown colour and the lack of stable granular structure.

Ou Reang Ov soil generally occurs higher in the landscape and on greater slopes than Kompong Siem Soil group. The fields where Ou Reang Ov Soil group occurs are almost always too well drained for flooded rice cultivation. Color of the soil is more brownish than Kompong Siem in the surface and distinctly reddish brown in the sub-surface. It has a greater abundance of gravel than in Kompong Siem. It does not key to Kompong Siem due to its dark brown colour and also due to its non-cracking behaviour.

Crop productivity and soil management

Crop performance on Ou Reang Ov Soil group was poor compared to Kompong Siem soil and to Labansiek soils although all formed on basalt in the same district (Tables 5, 6).

Table 5. Ranking of yield performance of crops on soils. Ranks were determined as follows: firstly relative yield for each crop on each soil was calculated as a % high input yield; secondly, relative yields across soils were ranked from 1 (highest) to 8 (lowest) for each crop; finally, ranks were summed across crop species to determine mean soil ranking

Soil group, phase	Soil rank	Maize	Mung bean	Soybean	Peanut
Kompong Siem	2.3	2	2	3	2
Labansiek, non-petroferric	3	1	7	1	3
Ou Reang Ov	4.3	4	2	4	7

Table 6. Grain yield (t/ha) of field crops in on-farm trials in early wet (EWS) and main wet (MWS) seasons. Values are means of four replicates

	Maize		Mung bean		Soybean		Peanut		Sesame	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
EWS										
13 Kompong Siem	1.75	-[A]	0.06	0.92	0.09	-	2.75	3.37	0	-
14 Ou Reang Ov	3.00	0.89	1.32	-	0.36	-	1.50	2.73	0	-
15 Labansiek	4.50	-	0	-	0	-	0	1.49	0	-
LSD (p<0.05)	*0.94*	*0.35*	*0.28*	*0.38*	*0.16*	0.27	*0.86*	*0.48*	*0.10*	-
MWS										
13 Kompong Siem	4.09	2.09	1.53	0.90	3.32	1.46	2.09	2.73	0	0
11 Ou Reang Ov	2.64	1.78	0.81	0.72	0.89	1.24	1.60	2.98	0	0
15 Labansiek		-	-	-	-	-	-	1.15	-	0.07
16 Labansiek	4.29	-	0.42	-	2.19	-	2.02	-	0	-
LSD (p<0.05)	*0.25*	*0.39*	*0.17*	*0.22*	*0.30*	*0.24*	*0.21*	*0.21*	*0.09*	0.09

[A] Crop failed to emerge or survive until maturity.

Ou Reang Ov soil is well drained throughout. The surface is prone to be hard when dry. Poor establishment was common for non-rice crops on this soil, especially in the early wet season. This may reflect hard surface condition when the soil is dry. Although the soil occurs on sloping land, due to high permeability and stable structure, it is not prone to water erosion. The sub-soil is generally friable and root penetration to 60 cm or deeper has been observed. The presence of abundant (40-80 % of soil volume), medium to coarse gravel in the sub-soil may limit soil water storage and make crops on this soil prone to drought.

The soil appears to have naturally high extractable P levels. Sulfur supply in the surface soil may be limiting for early growth but as roots penetrate deeper they access greater available S supplies. Other nutrients appear from soil analysis to be in adequate supply. A possible limiting soil chemical factor for deep-rooted Al sensitive species is sub-soil Al toxicity. However, Al saturation increased to 40 % at 45 cm depth and below on one site out of four, so the extent of Al toxicity limitation is probably not serious.

[1] While the peds of Labansiek soils are described as crumb structure, more correctly they should be described as granular peds. The peds of Labansiek soil will hereafter be referred to as granular.

Fertility capability class

Only four soil profiles have been analysed in total, so the results should be treated with some caution. Soils are low in extractable N and have moderate to low organic matter levels. Extractable P and K levels range from moderate to high. Extractable S levels were low in the surface layers but increased at depth. Other elements were generally adequate. Exchangeable Al is high in some profiles, particularly at > 20 cm depth but the prevalence of this condition and its implications for crop growth have not been defined.

Based on the Fertility Capability Classification (Sanchez *et al.* 2003), the Ou Reang Ov Soil group is classified as a $CCr^{++}d$. This indicates a clayey texture to at least 50 cm, dry soil conditions for > 60 days per year and abundant gravel. Some profiles also have the a^- condition modifier on account of > 10 % Al saturation in the top 50 cm of the profile.

Land capability

Ou Reang Ov soils are generally too shallow for rubber plantations. Given the low yield of upland rice (<1 t/ha) and the sloping, elevated landforms on which the soil occurs, growing other field crops should be more economical than upland rice. Major limiting factors are low soil water storage, and possible Al toxicity in the sub-soil for sensitive crops. The soil appears to drain well and is not prone to soil erosion even on slopes, but nevertheless protection of the soil from water erosion should be practiced. Crop yields on this soil are generally inferior to those on Kompong Siem and Labansiek Soil groups when fertiliser is applied. However, farmers who generally use little or no fertiliser, rate Ou Reang Ov soil as more productive for crops than Labansiek or Kompong Siem soils. Drought and acid tolerant crops like peanut and cassava may be more productive than soybean, maize, sesame and mung bean. Overall land capability for non-rice crops was rated as fair to good (Class 3 to 2), depending on low soil water storage and perhaps sub-soil pH.

General conclusion

The clayey soils of the hills and slopes of basaltic landscapes have high potential for non-rice cropping. Their relative proximity to markets and good-quality all-weather roads in Kampong Cham province adds to the potential for crop diversification.

The Ou Reang Ov Soil group appears to have the most significant limiting factors for crop production on the basaltic landscape. The abundance of gravel in the profile limits soil water storage which can be a severe constraint under the erratic rainfall regimes of Cambodia. The Ou Reang Ov Soil group was not previously described in CASC, although White et al. (1997) do refer to intermediate brown gravelly soils in the mid-slopes of the basaltic terrain which we have now classified as the Ou Reang Ov Soil group (Seng *et al.* 2005). Further assessment of this soil is needed in Cambodia to determine its prevalence and uniformity. Recent soil surveying in Ponhea Krek district has identified a significant area of the Ou Reang Ov Soil group, on the slopes of the basalt plateau.

Soil acidity is also a limiting factor, but the extent of limitation varies among sites. More research is needed to reliably identify the most severely acid profiles of Ou Reang Ov soil. Further the maximum depth at which sub-soil Al can cause significant loss in crop production needs to be determined. The extent and severity of Mn toxicity and possibly Mo deficiency on the acid soils needs better definition also.

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ប្រសិទ្ធិភាពនៃប្រភេទអ៊ីនុបន្ថែមនៃស្លឹកដំឡូងឈើ លើការលូតលាស់ និងការទប់ស្កាត់ប៉ារ៉ាសិត លើគោពូជក្នុងស្រុក និងកូនកាត់ នៅរដូវប្រាំងក្នុងប្រទេសកម្ពុជា

EFFECT OF PROTEIN SUPPLEMENT FROM CASSAVA LEAF SILAGE ON GROWTH PERFORMANCE AND NEMATODE PARASITES CONTROL OF LOCAL AND CROSSBRED CATTLE IN THE DRY SEASON IN CAMBODIA

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អត្ថបទសង្ខេប

ពិសោធន៍នេះត្រូវបានធ្វើក្នុងរយៈពេល ១២ សប្តាហ៍ នៅរដូវប្រាំង ចាប់ពីខែ មករា ដល់ខែ មេសា ឆ្នាំ ២០០៤ ដោយមានកសិករចំនួន ២១ គ្រួសារ នៅខេត្តកំពង់ចាម (ពូជគោក្នុងស្រុក) និងកំពង់ស្ពឺ (ពូជគោកូនកាត់) ចូលរួម ហើយក្នុងមួយគ្រួសារមានគោ ១ ក្បាល ។ គោក្រោយពីលែងឱ្យដើរស៊ីស្មៅតាមវាលស្រែ ពួកវាត្រូវបានបន្ថែមប្រភេទអ៊ីន ២០០ ក្រាម ក្នុងមួយថ្ងៃ នៃស្លឹកដំឡូងឈើផ្អាប់នៅពេលល្ងាច គណនាក្នុងទំងន់ ១០០ គីឡូក្រាម នៃទម្ងន់គោ។ កំណើនទម្ងន់គោត្រូវបានថ្លឹង និងពងព្រួនត្រូវបានរាប់ ។ គោពូជក្នុងស្រុកកើនទម្ងន់ ១០៩.៧ ក្រាម និងគោពូជកូនកាត់កើនទម្ងន់ ១៤៥.៣ ក្រាម ក្នុងមួយថ្ងៃ (P=0.845) ។ ចំនួនពងព្រួនបានថយចុះ នៅរយៈពេលតែ ២ សប្តាហ៍ នៅទីតាំងសិក្សាទាំងពីរ ក្រោយពេលចាប់ផ្តើមផ្តល់ស្លឹកដំឡូងផ្អាប់ ហើយក៏គ្មានការខុសប្លែកគ្នាលើចំនួនពងព្រួនដែលបានរាប់ចំពោះពូជ គោទាំងពីរផងដែរ។ ស្លឹកដំឡូងឈើផ្អាប់ អាចដើរតួនាទីសំខាន់ចំពោះការលូតលាស់ និងការទប់ស្កាត់ពពួកប៉ារ៉ាសិត សម្រាប់ការចិញ្ចឹមគោជាលក្ខណៈគ្រួសារនៅរដូវប្រាំងនៃប្រទេសកម្ពុជា ។

ពាក្យគន្លឹះ: ស្លឹកដំឡូងឈើផ្អាប់ គោពូជក្នុងស្រុក គោពូជកូនកាត់ កំណើនទម្ងន់ ប៉ារ៉ាសិត។

Abstract

The On-farm trail was carried out during the period of 12 weeks in the dry season from January to April 2004; using 21 local and crossbred cattle from 21 farm families in Kampong Cham and Kampong Speu provinces. Cattle after grazing were supplemented in the evening 200g of protein from cassava leaf silage (CLS) per day per 100 kg of live weight. The growth performance of cattle was measured and nematode parasite eggs were assessed. Both local and crossbred cattle gained 109.7 and 145.3 g/day respectively (P=0.845). Numbers of nematode parasite egg counts were declined in both locations; Damber and Trakiet villages in Kampong Cham and Kampong Spue provinces respectively; just after two weeks of the trial but no differences were found between the local and crossbreed cattle. Cassava leaf silage could play an important role in small scale cattle feeding in dry season in Cambodia for cattle growth performance and nematode parasites control.

Keywords: cassava leaf silage, local cattle, crossbred cattle, live weight gain, nematode parasite.

Introduction

Cattle play important role in the present farming system in Cambodia. Cattle beside draught power for land preparation, transportation of agricultural produce from farm and manure for the crops is a source indicating the farm family wealthy. However the care, management and feeding have not given adequate attention. The shortage of feed in the dry season and the poor quality of rice straw fed to cattle lead to poor performance particular when preparing them ready for land preparation on rice and other crops' cultivation in the following rainy season. Forcing them to plough land with poor nutrition creates possibility for poor health and illness. In fact there are local feed resources in term of quality and biomass yield to be explored for the particular feed shortages in the dry season. Preston and Leng, 1987 reported that in order to enhance the ruminant production when feeding low quality feed, a supplementation of a good quality feed optimizes essential nutrients required for them.

Cassava leaves have been reported by researchers as a potential feed supplement for cattle due to high protein content (Wanapat *et al*. 2000; Man and Wiktorsson, 2001). Without mentioning the increasing cassava plantation in several regions in Cambodia farmers can plant cassava for root production for family consumption and its leaves after root harvest can be preserved as hay or silage. However, the ensiling has been proved to be an excellent farm method to preserve cassava leaves without negative effect on its quality. A source of readily fermentable carbohydrates is necessary, and in the case of Cambodia 5% sugar palm syrup has been used in the preparation of silage from cassava foliage silage, which is low in fermentable carbohydrates (Chhay Ty *et al*. 2001).

Other interesting aspects of cassava leaf are the secondary plant compounds particularly condensed tannins play important role in the reduction of endoparasite infection (Hoskin *et al*. 2000; Kabasa *et al*. 2000; Molan *et al*. 2002). Researches have been successfully used cassava leaf silage for pigs (Khieu Borin *et al*. 2005; Chhay Ty *et al.* 2003) however a few studies have been carried with cattle in Cambodia. The aims of present on farm trial were to use cassava leaf silage as supplement to cattle fed rice straw in the dry season in Cambodia and to study its effect on endoparasites.

Materials and methods

Location and duration

An on farm experiment was carried out in two locations (i) Damber village of Kampong Cham province and (ii) Trakiet village of Kampong Speu province. Local breed and

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crossbreed were used in Damber village and Trakiate village respectively. The Office of Animal Health and Production in Kampong Cham and Medar Khmer Development Organization (MKD) assisted in the implementation of the trials in Damber and Trakiat villages respectively. The duration of the trial was twelve weeks (from 25 January to 19 April 2004) excluding the period for preparation and adaptation of the animals.

Farmer selection

Twenty one interested farm families participated in the trial. A total of twenty one local and crossbreed cattle; twelve in Damber village and nine in Trakiet village; were used for the trial. The criteria of farm families selection was based on experience of keeping cattle, own a few cattle, willingness to participate in the trial, availability of land to plant cassava, permanent residence in the villages, and willing to share experience with their neighbor.

Feed and feeding

The diet used for this on farm trial was from the result of an on station experiment carried out at CelAgrid. The result from this on station showed that when providing 200g of crude protein of cassava leaf silage (CLS) per day for 100kg live weight, cattle fed rice straw were significantly improved their live weight gain compared with other cattle supplemented CLS with lower level of crude protein (Fig. 1).

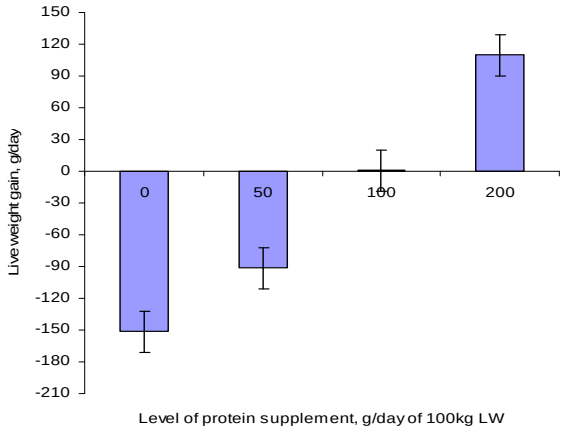

Figure 1: Growth rate of cattle supplemented with graded level of protein from cassava leaf silage.

For this on farm trial cattle were set free during the day for grassing the remaining rice straw in the paddy field and they were fed rice straw and CLS supplement while tying at home in the afternoon. Cattle were adopted to CLS for 10 days before starting to collect data. The amount of CLS given to cattle was calculated based on their live weight which was between 3-4 kg.

Making cassava silage

After harvesting cassava leaves were removed from petioles and were wilted overnight (approximately 12 hours) under the shade prior to ensiling. Materials to be used for ensiling were cassava leaves, sugar palm syrup, plastic bags, water, a bucket to mix water and sugar palm and an old motorcycle inner tube. First a plastic sheet was laid on the floor to avoid dirt mixed with the silage. For 100 kg of wilted cassava leaves, 5 kg of sugar palm syrup was used however to get a good mixture sugar palm was diluted in water with the ratio of 1 to 1. The solution of sugar palm and water was sprayed slowly on 100 kg of wilted cassava leaves then the well mixed product was placed into the plastic bags layer by layer and made strong pressure to extract air out from the bag and this created an anaerobic condition of good preservation for the silage. The bags with ensiling product were kept in a safe place to avoid damages made by animals. The ensiling period was 30 days prior feeding to cattle.

Farmers harvesting cassava foliage prior ensiling

Materials used and ensiling process

Measurement and analysis

The amount of CLS offer and refusal was recorded and representative samples were taken for chemical analyses: crude protein (CP), dry matter (DM), pH and Hydrocyanic acid (HCN). Cattle were weighed fortnightly and faeces were collected for nematode parasite eggs count following method of Hansen and Perry (1994). Faecal samples were taken directly from the rectum to count gastrointestinal parasite egg using Mc. Mater counting technique with saturated salt solution. A mixture of two grams faecal sample and 30 ml of salt solution were filtered through a tea strainer and then examined under 10X microscopic magnification. All nematode eggs counted in both compartments of Mc Master Chambers were added and multiplied by 50 to approximate number of eggs per gram of faeces.

The analysis was done on the DM followed the procedure of Undersander et al (1993). CP as indicated by N*6.25 and HCN were analysed according to the method of AOAC (1990). pH was measured by a digital meter with glass electrode.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using the General Linear Model option (GLM) of the MINITAB software version 13.2. Sources of variation were supplement, breed and error. The data for faecal egg counts were transformed by the power of $\log_{10}$ prior to analysis.

Result and discussion

Chemical composition of feed

Although not many grasses were found in the paddy fields cattle were allowed to grass during the day time and its quality was quite good compared with those available in the rainy season. Most farmers stored their rice straw after harvesting to feed their cattle during the dry season as well as in the rainy season however it had poor quality to satisfy the requirement of the cattle. This is one of the reasons leading to weight lost and vulnerability of cattle to diseases including parasites. In this case cassava leaves preserved as silage could play significant role to cattle feeding during the dry season due to its high quality to be use as supplement (Table 1). In addition the secondary plant compounds particularly condense tannin could play role on parasites control as reported by researchers (Seng Sokerya and Preston, 2003; Wanapat *et al*., 2000).

Table 1. Chemical composition of cassava leaf silage, rice straw and grass that the cattle were received during the trial

Feedstuffs	DM (%)	CP (%)	pH	HCN (mg/kg DM)
Cassava leaf silage	28.1	24.0	4.18	158
Rice straw	87.9	2.25		
Grass	18.4	12.5		

Feed intake and growth performance

Cattle of both breeds of the two on farm sites (Damber in Kampong and Trakiet in Kampong Spue) gained similar weight (P=0.845) during the trial period (12 weeks). The average daily weight gains were 109.7 and 145.3 g for local and crossbreed respectively (Table 2). The slight higher daily weight gain of crossbreed in Damber village might explain the better availability of natural grass in the paddy fields where cattle could grass during the day time. In addition, the genetic potential of crossbreed was also important to make better gain compared with local breed. The speculation is that sue to genetic potential the crossbreed cattle could gain even better when the supplement could be more than what was offered in this trial.

Table 2. Live weight gain, feed intake and feed conversion efficiency of local and crossbred cattle supplemented with cassava leaf silage in 12 weeks

	Local	Crossbred	SE	P
Weight gain				
Initial (kg)	131.1	129.6	15.38	0.893
Final (kg)	147.2	142.5	16.01	0.375
ADG (g/day)	109.7	145.3	35.55	0.845
Cassava leaf silage intake in average (g/day)				
DM	930.1	1096	146.58	0.428
CP	223.2	263.3	35.18	0.254
Feed conversion efficiency				
FCE[A]	15.55	9.86	3.43	0.428

[A] Feed conversion efficiency

Although not included as part of the trial, three cattle in each location as control group were also measured to assess their performance as they were mainly fed rice straw. These control cattle without feed supplement lost 156 g of weight per day which would mean that each lost approximately 13 kg of weight during 3 months in the dry season over the same period. Seng Mom et al. (2001) conducted an on station trial reported that when supplemented fresh cassava foliage at 3% of live weight on DM basis to local cattle fed rice straw and urea molasses (300g/day) gained 210 g per day. This higher gain might due to the additional supplement of urea-molasses. Leng et al. (1991) reported that the rumen supplement of fermentable nitrogen increased microbial growth resulting better rumen digestion, feed intake and a balance of nutrients available for metabolism. Granum et al. (2003) supplemented cassava hay (well sun-dried cassava foliage) of 1 kg per head per day (900g DM) to the grazing Brahman heifer on a mixed pasture natural plots for six weeks gained 23.8g per day whereas non supplemented cattle lost weight. The reason of poor gain or weight lost might be due to poor quality pasture (mature grasses). When given a supplement of 0.44 kg (DM) cassava hay per day to cattle fed cassava chip (300g/head/day), fresh cassava root residue (500g/head/day) and rice straw over 60 days cattle gained 287g of weight per day (Tran Quoc Viet and Dao Duc Kien, 2005).

Nematode parasite egg count

Number of nematode parasite eggs' count was declined similarly for cattle in both breeds and locations since the first fortnight of the experimental period (Fig. 2). The number of nematode parasite eggs count was ~ 250 epg and was reduced ~100 epg after the second week of the trial. This reduction could have the effect from the plant secondary compound as well as the supplement of protein from CLS. However, similar results were reported that the reduction of faecal egg count (FEC) after feeding cassava foliage, in any form (fresh, dried and silage), assuming due to tannins compounds (Nguyen et al., 2003; Dung et al., 2005; and Tran Quoc Viet and Dao Duc Kien, 2005). Netpana et al. (2001) and Granum et al. (2003) found the reduction of FEC in dairy cattle, beef cattle as well as in swam buffaloes when supplemented cassava hay of 1 kg per head per day. An experiment carried out in Cambodia found lower FEC in goats when fed fresh cassava foliage, brewery spent grain and natural cut-grass (Seng and Rodriguez 2001 and Seng and Preston 2003). Ho Bunyeth and Preston (2005) reported that a supplement of cassava foliage silage on grazing goats in lowland (in Kandal province) and highland (Pursat) areas of Cambodia had a significant effect on the declination of FEC as compared to the goats with cassava hay supplement.

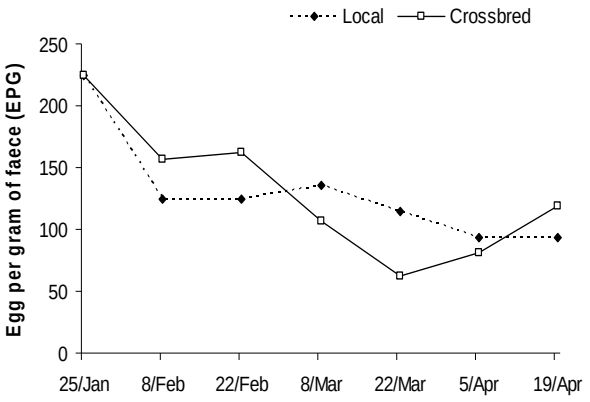

Figure 2. Effect of supplemented cassava leaf silage on nematode parasite eggs count of local and crossbred cattle.

Conclusion

Cassava leaves preserved as silage could be one of the local feed resources particularly for the dry when there is shortage of feed. Cassava leaf silage was not only improved cattle weight gain but also contributed to the overall parasites control and thus reducing of buying de-worming parasites especially for small scale farm families who might have shortage of cash to do so.

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ការសិក្សាអំពីសាថតានៃបញ្ហារបស់ពួកសត្វកកេរលើដំណាំកសិកម្មនាតំបន់ទំនាបនៅក្នុងប្រទេសកម្ពុជា

A BACKGROUND STUDY INTO PEST RODENT PROBLEMS IN CAMBODIAN LOWLAND AGRICULTURE

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អត្ថបទសង្ខេប

ពពួកសត្វកកេរចង្រៃបង្កវរផលប៉ះពាល់ជាវិជ្ជមាននៅមុនពេល និងក្រោយពេលប្រមូលផល ដល់ប្រជាកសិករនៅទូទាំងអាស៊ីអាគ្នេយ៍ ប៉ុន្តែនៅក្នុងប្រទេសកម្ពុជាមានការយល់ដឹងពីបញ្ហានេះតិចតួចនៅឡើយ។ បច្ចុប្បន្ន ការសិក្សាស្រាវជ្រាវអំពីប្រភេទសត្វកកេរដែលមាននៅតាមភូមិ និងវាលស្រែត្រូវបានធ្វើឡើងនៅក្នុងប្រាំមួយខេត្ត ដែលតំណាងអោយតំបន់ដាំស្រូវសំខាន់ៗនៃប្រទេសកម្ពុជា។ ការដាក់អន្ទាក់ចាប់ពពួកសត្វកកេរត្រូវបានធ្វើឡើងអស់រយៈពេល ១០ ខែ ហើយការសម្ភាសន៍កសិករត្រូវបានធ្វើឡើងនៅកន្លែងដូចគ្នា ដើម្បីប្រមូលព័តមានអំពីធនធានធម្មជាតិ ពេលវេលា និងកម្រិតបំផ្លាញរបស់សត្វកកេរលើប្រភេទដំណាំផ្សេងៗ។ សរុបទាំងអស់មានសត្វកកេរ ៩ ប្រភេទ ត្រូវចាប់បាន។ មានការខុសគ្នាយ៉ាងខ្លាំងរវាងការចាប់បាននៅក្នុងភូមិ និងនៅតាមវាលស្រែ។ ប្រភេទកណ្តុរធម្មតា ឬក្រហម (*Rattus argentiventer* Robinson & Kloss) ដែលមានច្រើននៅតាមវាលស្រែនៃប្រទេសវៀតណាមភាគខាងត្បូង ត្រូវបានរកឃើញមាននៅក្នុងខេត្តបីភាគអាគ្នេយ៍នៃប្រទេសកម្ពុជា។ ប្រភេទកណ្តុរនេះគ្មានវត្តមាននៅភាគពាយព្យនៃប្រទេសកម្ពុជាទេ ទោះបីតំបន់នេះជាជម្រកសមរម្យសម្រាប់វាក៏ដោយ។ ប្រភេទកណ្តុរ *Rattus aexulans* Peale មានច្រើននៅតាមភូមិគ្រប់ទីកន្លែង ហើយប្រភេទកណ្តុរ *Mus musculus* L. មិនត្រូវបានរកឃើញនៅគ្រប់ទីកន្លែងទេ។ ប្រភេទកណ្តុរ *Rattus rattus* L. នៅក្នុងស្រែត្រូវបានរកឃើញមានចំនួនប្រហាក់ប្រហែលគ្នានឹងនៅតាមផ្ទះ។ កសិករបានរាយការណ៍ថា ការបំផ្លាញដោយពួកសត្វកកេរមានកម្រិតប្រែប្រួលពីអប្បបរមា ទៅអតិបរិមា ហើយជាទូទៅ ការបំផ្លាញលើដំណាំមានកំរិតខ្ពស់ ច្រើនកើតមានឡើងនៅរដូវប្រាំងជាងនៅរដូវវស្សា។ កសិករដែលមានស្រែស្ថិតនៅជិតស្ទឹង ព្រៃ ឬជម្រកផ្សេងទៀតរបស់ពួកសត្វកកេរបានរាយការណ៍ថា មានការបំផ្លាញច្រើនជាងកសិករដែលមានស្រែនៅឆ្ងាយ។

ពាក្យគន្លឹះ: ពួកសត្វកកេរចង្រៃ ស្រូវតំបន់ទំនាប Rattus argentiventer

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Abstract

Pest rodents are a significant pre and post-harvest problem to rice farmers throughout Southeast Asia but little is known of the extent or severity of this problem in Cambodia. The current study investigated the rodent species found in village and field habitats in six provinces of Cambodia, distributed across the major rice growing areas. Trapping for pest rodents was carried out for 10 months and farmer interviews were conducted at the same locations to gather information on the nature, timing and severity of rodent damage in different crop types. A total of nine species of rodents were captured. Strong contrasts were found between the captures in the village and field habitats. *Rattus argentiventer* Robinson & Kloss, the dominant rice field pest in southern Vietnam, was found only in the three surveyed southeastern provinces of Cambodia; this species appears to be absent from the north-west, despite the suitability of habitats in this area. The dominant village pest everywhere is *Rattus exulans* Peale and *Mus musculus* L. was not found at any location. *Rattus rattus* L. alone was found in roughly equal numbers in field and village habitats. Farmers reported varying levels of damage caused by rodents, from very mild to extreme, with higher damage usually sustained by the dry season crop rather than the wet season crop. Farmers with fields located close to rivers, forest or other rodent refuge habitats reported higher damage than those further away.

Keywords: Pest rodents, lowland rice, rattus argentiventer.

Introduction

Rodents are a chronic problem in Cambodian agriculture with significant documented pre-harvest losses and unknown but potentially significant post-harvest losses.

Research in the area of rodent management has been hindered in Cambodia by an almost complete lack of information on the identity, distributions and ecology of the pest rodent communities. The effectiveness of future rodent research and management projects in Cambodia will be greatly enhanced by the acquisition of this basic information.

A previous investigation into rodent damage and control methods in Cambodia used interviews and participatory methods with farmers in eight provinces (Leung *et al*. 2002). They found that pest rodents were considered a problem by most farmers throughout Cambodia. They caught rodent specimens in Svay Rieng and Siem Reap and reported some of the local names for the rats but did not attempt to comprehensively identify the species or define the distributions of rats found in agricultural regions of Cambodia.

The current study was set up to investigate the taxonomic composition of rodent communities found in human-altered landscapes and to further examine the extent of the problem of pest rodents in lowland rice growing areas in Cambodia. It was coordinated by the Cambodian Agricultural Research and Development Institute (CARDI) with

strong involvement from staff of the Department of Agriculture in each participating province and with the financial support of the Cambodian Agricultural Research Fund (CARF).

Methods

Six provinces were involved in the project (Fig.1 & Table 1). In March 2003, agriculture staff in three provinces; Kampong Chhnang, Kampong Cham and Takeo (Fig.1) were trained in collection and preservation of rats. They conducted regular monthly trapping in various habitats in their region for 10 months (March-December). In conjunction with the training, local agriculture staff and CARDI staff conducted farmer group interviews. Four groups of farmers participated in group discussion and two participatory activities – a cropping calendar and drawing a village map. The information from these activities formed a basis for understanding the local rodent problems.

In December 2003 a further six agriculture staff from three provinces (Battambang, Banteay Meancheay and Siem Reap (Fig.1) were trained in rodent collection and preservation techniques. They carried out trapping as with the other provinces in 2004. As with the earlier training, six farmer group interviews were again conducted in conjunction with the training to provide the provincial staff with a broad basis for understanding local rodent problems and discussing these problems with farmers.

All captured rodents were identified by the primary author from the preserved skins. Tissue samples were also taken from some specimens to confirm the species identifications using molecular analysis of DNA and by comparing them to other specimens from the broader region. Voucher specimens were held at CARDI, representatives were also lodged at the Australian National Wildlife Collection, CSIRO, Canberra, Australia.

Figure 1. Map of Cambodia showing project survey sites.

Table 1. List of trapping villages, communes and provinces surveyed

Province	District	Commune	Village
Battambang	Battambang	Watkor	Damnak Luang
		Omal	Salabalad
		Tameun	
B. Meannchey	Mongkul Borey	Preah Sre	Banteay Neang
	Svay Chek	Rolous	Steung
Siem Reap	Pourk	Kao Por	Kork Por
			Krabey Riel
		Krabey Riel	Popeal
K. Cham	Chemkar Leu	Svayteap	Promat Dae
		Lvea Leu	Kraleng Leach
			Kbal Hong Thmei
		Speu	Speu
K. Chhnang	K. Chhnang	K. Chhnang	Tnal Ampil
			Damnak Popoul
			Sre Pring
		Phsa Chhnang	Trapeang Ty
	Chulkiri	Kampong Os	Phoum Kandal
Takeo	Daunkeo	Baray	Kan Kav
	Kirrivong	Ang Prasat	Wat Svay
	Prey Kabass	Kampeng	Talung

Results

From the six provinces, over 1000 rats were captured over a ten month period (March-December) and identified to species. The trapping results show a significant difference in the species composition between the captures from the house/village and the field captures, and also some major differences between certain provinces. The capture results are presented in the Table 2. The following results are based on a combination of these trapping results and information obtained during the farmer group discussions in each province. The results are presented by provincial division to give an idea of the variation in the pest rodent problem across the country.

Kampong Cham

Three species (*Rattus norvegicus* Berkenhout *R. exulans*, and *R. rattus*) dominate the captures in and around houses with *R. exulans* the most abundant of these (Table 2). *Rattus exulans* and *R. norvegicus* are sometimes also caught in the fields but usually only in fields close to villages. *Rattus rattus* and *R. exulans* are both highly arboreal and usually make nests in trees or roofs of houses. In contrast, *R. norvegicus* lives in burrows. These species are presumably the most important post-harvest pests and may also be potentially important disease vectors through contamination of rice stores and other contact with people.

Four species (*Rattus losea* Swinhoe, *R. argentiventer*, *R. exulans*, and *Bandicota indica* Bechstein) together dominate captures in or adjacent to rice fields (Table 2). These species (apart from *R. exulans*) were captured only rarely in and around houses and probably do not live and breed within the village environment. *Rattus argentiventer* makes up more than 50% of all field captures, with lesser numbers of *R. losea*, *R. exulans* and *B. indica*. Local farmers we inter-

viewed also identified this species as the most important rice pest. Two *Mus* species have been identified from Kampong Cham; *Mus cervicolor* Hodgson and *Mus caroli* Bonhote. They can be locally common, although they are rarely trapped in the field. They may be a more significant pest than indicated by the results of this study.

In Kampong Cham rodents can be a significant pre-harvest problem, especially in the dry season when some farmers report extreme losses of up to 100%. However, other farmers claim to suffer no damage. In general, the level of damage seems to be related to the proximity of a field to the flood waters of the Mekong River. The fields close to the flood waters generally have higher damage levels than those further away. The most common rodent control method is rodenticide. Farmers in Kampong Cham had been using rodenticide since 1985; however, farmers we interviewed estimated that only 70% need to use it.

Kampong Chhnang

Kampong Chhnang has an area of 106,574 ha of cultivated land; approximately 8% is dry season recession rice, the remainder of the rice crop is wet season rice (Nesbitt 1997). In Kampong Chhnang house captures are dominated by *R. exulans* which made up 78% of the total for this habitat. Other species captured in houses and around the villages are *R. norvegicus, R. rattus* and the house shrew *Suncus murinus* L. (Table 2). The latter species is not a rodent; it is an omnivore and it is unlikely to cause significant post-harvest losses. Indeed, it may do more good by cleaning up household insects and food scraps. *Suncus murinus* is commonly seen in larger towns and cities in Cambodia.

Kampong Chhnang field trapping results showed high numbers of *R. losea, R. argentiventer* and *B. indica*, with fewer individuals of *R. rattus* and *Bandicota savilei* Thomas. Both *R. argentiventer* and *R. rattus* were also caught in cucumber fields.

Takeo

Takeo has a cultivated land area of around 222,483 ha and 19% of this is dry season recession rice grown after the recession of the Mekong floodwaters (Nesbitt, 1997). In Takeo the dominant species in the fields was *R. argentiventer* which is also the most common rodent in the Mekong Delta in Vietnam (Aplin *et al.* 2003). Interestingly, very few *R. losea* (1%) were caught in the fields in Takeo; in general, and they seem to prefer more complex and slightly elevated habitats to the inundated rice fields of the delta. *Bandicota indica* and *B. savilei* were also caught, but both are much less common than *R. argentiventer*. *Rattus rattus* was caught both in the houses and the fields but not in high numbers (Table 2). The most common village pests were *R. exulans* and *R. norvegicus*. Small numbers of house shrews were also caught in the villages.

Takeo farmers we interviewed used to grow only deep water rice. However, they now grow only dry season recession rice with the use of chemical fertilisers. This change has probably increased productivity and may have led to a rise to dominance of the local population of *R. argentiventer*. All farmers use rodenticides but this practice commenced only within the last 6-10 years.

The farmers reported post harvest losses of around 20 to 30%. About four years ago many farmers began storing their grain in sacks instead of bamboo stores because this was a more flexible way to store it. However, rats are still able to eat the grain by chewing holes through the sacks. Interestingly, unlike any other province in this study, *R. argentiventer* is fairly commonly caught in the villages in Takeo and is probably a significant contributor to post-harvest losses.

Battambang

Battambang has a total of 203,643 ha of cultivated land. Many crops are grown as well as rice, including corn, potato, banana, papaya, mango, milk fruit, orange, longan, sesame, coconut, jack fruit, lime and morning glory. Before 1979, farmers grew wet season rice only. However, they now grow dry season rice as well. Some of the crops other than rice are said to suffer light damage by rats.

No *R. argentiventer* were caught in Battambang and the farmers identified *Bandicota* as causing the most damage in the fields. However, the smaller rodents (*Mus* species and *R. exulans*) were also said to be very abundant and to sometimes cause significant pre-harvest loss. This may be the case even though no *Mus* were caught in the fields during our study period. *Rattus losea* and *B. indica* dominated our field captures (Table 2).

Although rodenticides have been used in the area for at least 20 years, not everybody uses them. Many people expressed concern that rodenticides could be harmful to other animals and to the health of people. Some people say that forest habitat was a major source of rats and that since the nearby forests have been cleared there are fewer rats than before. The farmers we interviewed in Battambang reported very low post-harvest losses of 3-5%. *Rattus exulans* and *R. norvegicus* were the only species caught in the houses.

Banteay Meanchey

Farmers here told us that some people are now able to grow dry season rice due to irrigation whereas in the past they could only grow rice in wet season. One village we interviewed had irrigation and grew both wet and dry season rice. One other did not have access to flood recession land and grew only wet season rice. Since the early '90's they have had access to improved rice varieties and fertilisers and to composting techniques. The farmers growing two crops reported a much higher loss in the wet season than in the dry season. In contrast, the farmers in the village where dry season cropping was rare reported the wet season rice crop having relatively little damage. This could be due to the concentration of rats during the dry season on just a few fields. *Rattus argentiventer* was again absent and field captures were dominated by three other species (*R. rattus* and *R. exulans, B. indica*). *Mus* species, *R. losea* and *R. norvegicus* were less commonly captured. All of these species were also captured in the village habitat, with *R. exulans* making up more than 70% of captures (Table 2).

Some crops other than rice are grown in the region, including banana, coconut, mango and many types of vegetables. Farmers we interviewed reported a loss of 5-10% for stored grain which is stored for the whole year in wooden or bamboo grain stores or in sacks in the house.

Siem Reap

In contrast to the south eastern provinces, *Mus cervicolor* appears to be a significant post harvest pest in Siem Reap. Many were caught in the rice stores, possibly because the houses trapped were adjacent to rice fields. The main field pests were *R. losea* (52%), *M. cervicolor* (15%) and *R. rattus* (18%) (Table 2). As with Battambang and Banteay Meanchey, no *R. argentiventer* were caught.

The farmers described a strong link between the presence of forest (low flooded scrub also termed 'forest' by farmers) and high rat damage. Where 'forest' has been removed, rat damage was said to be significantly reduced. The absence of the rice field specialist, *R. argentiventer,* may mean that any large areas of rice devoid of 'forest' remain damage free.

The farmers reported fairly low post-harvest losses (10-20%) and pre-harvest damage of 10-30%.

Table 2. Rodent composition of the house and field captures in each province

Species	KCM (%)		KChh (%)		Takeo (%)		BB (%)		BM (%)		SR (%)	
	H	F	H	F	H	F	H	F	H	F	H	F
S. murinus	0.0	0.0	11.0	0.0	8.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0
R. norvegicus	8.0	3.0	10.0	2.5	17.0	0.0	20.5	2.0	7.0	3.0	5.0	3.0
R. exulans	74.0	13.0	78.0	7.0	37.0	1.0	79.5	10.0	75.0	24.0	33.5	6.0
Mus spp.	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	15.0	32.5	15.0
R. rattus	13.0	6.0	1.0	6.0	15.0	15.0	0.0	5.0	10.5	29.0	15.0	18.0
R. losea	1.0	14.0	0.0	29.0	0.0	1.0	0.0	30.0	1.5	4.0	7.0	52.0
R. argentiventer	2.0	51.0	0.0	28.0	23.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0
B. indica	1.0	11.0	0.0	25.0	0.0	23.0	0.0	53.0	4.0	25.0	7.0	6.0
B. savilei	0.0	1.0	0.0	2.5	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Pre-harvest loss	100		-		-		-		-		10-30	
Post-harvest loss	-		-		20 -30		3-5		5-10		10-20	

Rodent distribution

Table 3 summarises the general distributions of each main pest rodent species in Cambodia, based mainly on the results from this study. Most of the pest rodents are widely distributed, with the exception of *R. argentiventer* (Table 3). However, due to the limited time frame and trapping effort in this study, some species may have been overlooked in places where they do occur. However, any omissions are probably not major pests in the area in question, hence their elusiveness in this study. The following notes summarise the state of current knowledge of the rodent pests in Cambodia. The species are listed in generic groups.

Bandicota

- *Bandicota indica* (Bandicoot rat): has a continuous distribution throughout the lowland rice growing areas and it may also occur in upland regions where there is some valley rice or swampy habitat. They are very common where conditions are favourable. This species is a major contributor to pre-harvest losses of rice.
- *Badicota savilei* (Lesser Bandicoot rat): appeared to have a patchy distribution and is much less common than *B. indica*. Although there were no actual records from the north west half of Cambodia, they may be found there as they occur in neighbouring parts of Thailand (Aplin *et al.* 2003).

Rattus

- *Rattus rattus* (Large house rat): 'Mekong' type (more than one species is currently included in *R. rattus* (Aplin *et al.* 2003); the 'Mekong' type is found primarily in Cambodia and southern Vietnam). It is found in most habitats in the south and east of Cambodia and they are common in the fields in these areas. *R. rattus* also occurs in the northwest of Cambodia but it was uncertain yet whether they are the same species as the type in the south east.
- *Rattus argentiventer* (Rice field rat): appears to be restricted to the south east half of Cambodia. In this area it is very common, especially in lowland rice field habitats. There is no obvious environmental reason for its absence in northwest of Cambodia. In the regions where it does occur it is a major rice field pest.
- *Rattus losea* (Lesser rice field rat): found throughout most of the rice growing regions of Cambodia, although it appears less common in the Mekong Delta region of Takeo and (probably) Svay Rieng and Kandal. In areas where their ranges overlap, *R. argentiventer* appears to be more abundant than *R. losea*.
- *Rattus norvegicus* (Brown rat): found throughout Cambodia but usually as a commensal, living in cities, towns and some villages. They are only sometimes encountered as a field pest.
- *Rattus exulans* (Small house rat): very common in villages and cities throughout Cambodia (including Phnom Penh). They are also sometimes found as a field pest. This species is the most common village rodent and probably the cause of a significant amount of post-harvest losses of stored grain.

Mus

- *Mus cervicolor* (field mouse): probably found throughout Cambodia, despite patchy records. This species favours lowland grassy habitats (including rice).
- *Mus caroli* (field mouse): few records, and none from the northwest.

Suncus

- *Suncus murinus* (house shrew): common in large cities and towns throughout Cambodia, also present in some smaller village communities.

Table 3. Presence or absence of field rodents and the house shrew in seven Cambodian provinces

Species	Phnom Penh	Kampong Cham	Kampong Chhnang	Takeo	Battambong	Siem Reap	Banteay Meanchey
Bandicota indica	+	+	+	+	+	+	+
B. savilei	+	+	+	+	?	?	?
Rattus rattus	+	+	+	+	+	+	+
R. argentiventer	+	+	+	+	-	-	-
R. losea	?	+	+	+	+	+	+
R. norvegicus	+	+	+	+	+	+	+
R. exulans	+	+	+	+	+	+	+
Mus cervicolor	+	+	?	?	?	+	+
M. caroli	?	+	?	?	?	?	?
Suncus murinus	+	+	+	+	?	+	?

Local Names

The local names for rats were collected during the group interviews. Farmers were shown skinned, preserved or live specimens. Usually they distinguished at least three different types which were recognised mainly by size: large (*Bandicota*), medium sized (*Rattus*) and small (*Mus*) (Table 4). However, often more than one name was given within each size class, usually based on differences in colour or habit. For example, in Takeo, the name *kondol bay* was used to distinguish *Rattus* that are of large size, a reddish colour and that are seen living in fields and houses. These are most likely individuals of *R. argentiventer*. The name *kondol prameh* was used for slightly smaller rats that live in houses and villages; this probably includes *R. rattus* and *R. exulans*. The species of *Rattus* that are found in Cambodia were very difficult to distinguish morphologically but their habits are quite different. Farmers with more severe problems will tend to be more observant of the rats in their fields and houses, and such people usually distinguish more types and have more names for the pest rodents.

During this study we were unable to collect local names for *S. murinus* and *R. norvegicus* because the farmers involved in the discussions did not recognise these species; both are generally found in more built-up areas.

Table 4. Local names of pest rodent species in six Cambodian provinces. All local names in this table are preceded by 'Kondol' which means rat. This is not an exhaustive list

Province	*Bandicota*	*Rattus argentiventer*	Other *Rattus*	*Mus*
		Thomada	Prameh	Tooch
K. Cham	Praeng	Bay		Rormeas
		Krahorm		
		Bangkang		
K. Chhnang	Praeng	Krahorm		Angkarm
Takeo	Praeng	Bay	Prameh	Mrech
		Doong	Angkor	Angkarm
			Phteah	
Battambang	Praeng		Bangkang	Prameh
			Bangkang	Prameh
B. Meanchey	Praeng		Krahorm	Angkarm
			Sambok	
Siem Reap	Praeng		Sambok	La-eth
				Sboov

Discussion

Cambodian pest rodent communities

This study has documented the rodent communities found in lowland rice growing areas of Cambodia. The areas included in this study are all modified environments. Other species may be expected in upland regions and areas that retain forest cover. As a note of interest to conservation, none of the forest species found in Cambodia and other parts of south-east Asia were caught in lowland agricultural habitats. The only species that is found in forest as well as rain-fed lowland and flooded rice environments is the local form of *R. rattus* – the 'Mekong' type. Another note of interest is that there are no *Mus musculus* records from Cambodia.

Agricultural rodent pests are a significant problem for farmers throughout Cambodia. However, while most of the pest rodent species are widespread in Cambodia, the extent of the problem and the particular species causing the problem often depends very much on localised conditions. In many areas, farmers who reported the most severe problems tend to have fields close to the edge of floodwaters, close to flooded scrub, or close to villages or other upland cropping areas that provide refugee for rodents. In contrast, farmers who had rice fields away from these sorts of habitats often reported little or no field damage by rodents.

More general rodent problems, affecting a majority of farmers, were reported in the Mekong delta province of Takeo where the rice field rat (*R. argentiventer*) is dominant in field captures. Similar problems are expected in the adjacent provinces of Svay Rieng and Kandal. *Rattus argentiventer* is a specialist of lowland rice fields and is a major pest in the Vietnamese portion of the Mekong Delta, in the Red River Delta of northern Vietnam, and also in parts of Malaysia, peninsular Thailand and Indonesia (Aplin *et al.* 2003). Although this species is found in other south eastern provinces of Cambodia, in those areas it does not seem to reach such high numbers nor does it seem to occupy the larger areas of rice, as it does in the delta. This may be due to the increased diversity of species in other areas, perhaps reflecting the more complex habitats available.

It is possible that *R. argentiventer* may one day reach the north western provinces of Cambodia, as there are good conditions for it there and continuous suitable habitat from there to its current locations. (Leung *et al.* 2002) identified specimens of *R. argentiventer*, *B. indica* and *M. musculus* from Svay Rieng, and reported the dominance of *R. argentiventer* in their captures (it is possible that the *M. musculus* was either *R. exulans* or another *Mus* species, as no other *M. musculus* were recorded during the present study and the identification of that specimen has not been confirmed). They also identified *R. losea*, *R. rattus* and *B. indica* from Siem Reap but no *R. argentiventer*. Interestingly, the provinces without *R. argentiventer* reported a very low post-harvest loss. Although *R. argentiventer* is not usually considered a major post-harvest pest, in Takeo where it is the dominant species it was frequently caught in the rice stores. However, in Kampong Cham and Kampong Chhnang it was rarely if ever caught in rice stores.

The small house rat (*R. exulans*) was caught primarily in the villages and houses in Cambodia. In Banteay Mincheay where only four other species were present *R. exulans* was relatively commonly caught in the fields. Across most of its wider geographic range it is found in villages and household gardens (Aplin *et al.* 2003). However, it is a significant field pest in Hawaii where it infests sugar cane despite the presence of *R. norvegicus* and *R. rattus* (Nass, 1977), and it is also common in sugar cane and rice in Malaysia (Wood & Liau, 1978), Thailand and the Philippines (Aplin *et al.* 2003). It is possible that this species is restricted to village habitats where there is a high diversity of field pest species, thereby limiting its ability to compete in the fields.

Rattus rattus is a versatile rat that can live in both burrows and in tree nests. It seems to prefer areas that include either land that is not flooded or patches of good woody vegetative cover. It does not seem to be a major pest in large areas of monoculture rice production. In the more mountainous regions of Southeast Asia, *R. rattus* is often found as the main field and household pest.

Local names

The local names ascribed to rats seem to vary from province to province, but with some overlaps. The one constant is the name for *Bandicota indica* - *kondol praeng*. It is

unclear why this might be so other than that this species is the most distinctive and widespread of all the pest species. Generally farmers do not distinguish between different rat species of similar size. For example, *R. rattus*, *R. losea* and *R. argentiventer* are often identified by the same name. Similarly, *B. indica* and *B. savilei* are both included under *kondol praeng*. In some parts of Kampong Cham where *Mus* are not major pests, these species are thought to be only the babies of the larger rats. In general if a farmer has a problem with a particular species of rat, they seem also to have a name for the species. Similarly, the more pronounced the rodent problem, the more they tend to know about them (Frost & King, 2003). In discussions about local rat problems it is very useful to employ the local names used by farmers, as this increases understanding on both sides.

Rodent control activities

Many of the farmers interviewed during this study were using rodenticides. Those who did not use rodenticides often said it was because they were afraid of the potential harm to other animals and to people. Nobody we interviewed knew the name of the rodenticides they used, only that they bought it from the market or rodenticide sellers. This highlights the need for more information about rodenticides, how best to use them and which ones are better for the health of their local environment.

Farmer group discussions and participatory methods

The participatory methods used in the initial farmer group discussions proved to be very useful as visual aids for discussion. The cropping calendar and the village map were conducted at the start of each discussion session to get the farmers thinking about their rat problems. The calendars and maps were drawn on paper and provided a visual focal point for the discussion and served to identify issues and questions beyond those already listed. These activities were also quite fun and involving, and acted to 'break the ice' in new discussions. Having rodent specimens available for farmers to look at also promoted discussion and understanding. A limitation of this study was perhaps the lack of experience of the agricultural staff with good techniques for discussion. It is important that discussion groups such as those in this study are conducted pragmatically, and that interesting comments and observations from the farmers are thoroughly followed through at the time.

Further research

It is clear from this preliminary study that there were significant differences in rodent community composition in different regions and habitats across Cambodia. As a continuation of this study, it would be useful to examine the relationship between rodent species and habitat on a smaller scale. The targeting of management measures could be refined with such information. It would also be interesting to know whether *Rattus argentiventer* is spreading across Cambodia, as this major pest could potentially cause extensive damage should it invade the North West provinces sometime in the future.

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ពូជពោតចំនួនពីរពូជត្រូវបានរំដោះនៅប្រទេសកម្ពុជា

TWO OPEN POLLINATED MAIZE VARIETIES RELEASED IN CAMBODIA

Sakhan Sophany[*]*, Men Sarom and Ouk Makara*

អត្ថបទសង្ខេប

ដំណាំពោតប្រហែលជាត្រូវបាននាំចូលដាំដុះក្នុងព្រះរាជាណាចក្រកម្ពុជា ក្នុងសតវត្សរ៍ទី ១៧ - ១៨ ។ យោងតាមសារៈសំខាន់សេដ្ឋកិច្ច និងផ្ទៃដីដាំដុះ ពោតគឺជាដំណាំទីពីរបន្ទាប់ពីដំណាំស្រូវ។ ដំណាំពោតត្រូវបានដាំដុះក្នុងរដូវវស្សា នៅលើដីមានជីជាតិតាមបណ្តោយទន្លេ និងលើដីក្រហមនៃដងខ្ពង់រាប។ ពិសោធន៍ជាច្រើនបានធ្វើនៅក្នុងខេត្តកណ្តាល និងកំពង់ចាម ក្រុងប៉ៃលិន និងនៅកាឌីក្រុងភ្នំពេញ។ លក្ខណៈវិនិច្ឆ័យសំខាន់ៗក្នុងការជ្រើសរើស គឺមានរយៈពេលចេញផ្កាឈ្មោល និងញី កំពស់ដើម កំពស់ផ្លែ និងទិន្នផលគ្រាប់។ ស្រឡាយបង្កាត់របស់ CIMMYT ចំនួន ៧០ ស្រឡាយ ដែលក្នុងនោះមានប្រភេទពោតធម្មតា និងប្រភេទពោត ដែលមានគុណភាពប្រូតេអ៊ីនខ្ពស់ បាននាំចូលមកធ្វើការពិសោធន៍ ប្រៀបធៀបជាមួយពូជពោតកសិណក្នុងស្រុកចំនួនបួន ក្នុងរដូវវស្សាឆ្នាំ ២០០៣ និងរដូវប្រាំងឆ្នាំ ២០០៤។ ស្រឡាយបង្កាត់ចំនួនដប់ ដែលក្នុងនោះមានប្រភេទពោតគុណភាពប្រូតេអ៊ីនខ្ពស់ចំនួនបី ត្រូវបានជ្រើសរើសយកមកពិសោធន៍ជម្រើសទិន្នផលនៅកាឌី កំពង់ចាម កណ្តាល និងប៉ៃលិន រយៈពេលពីររដូវសម្រាប់ពីរឆ្នាំជាបន្តទៀត។ លទ្ធផលបានបង្ហាញថា ស្រឡាយបង្កាត់ COTAX-TLA-S0031 និង S-99TLWQ-HG-AB មានការបន្សាំបានល្អនៅក្នុងមជ្ឈដ្ឋានដាំដុះផ្សេងៗ ហើយមានទិន្នផលគ្រាប់ច្រើនជាងពូជ របស់កសិករពី ៥ ភាគរយ ទៅ ៧ ភាគរយ។ ដូចនេះស្រឡាយបង្កាត់ទាំងពីរនេះត្រូវបានរំដោះជាពូជជូនកសិករប្រើប្រាស់ដោយដាក់ឈ្មោះ **ល្បើងមង្គល** សម្រាប់ COTAXTLA-S0031 និង **សជ័យ** សម្រាប់ S-99TLWQ-HG-AB ។

Abstract

Maize was possibly introduced and grown in Cambodia in late 17th to 18th century. It is the second food crop after rice in term of cultivated area and economical importance. Maize is grown in the wet season on the fertile soil along the river delta and the red soil of upland slopes. Experiments were conducted in three provinces of Kandal, Kampong Cham, and Pailin and at the CARDI field station in Phnom Penh. Main selecting criteria were days to male and female flowering, plant heigh, ear height, and grain yield. Seventy open pollinated breeding lines of normal and quality protein maize introduced from CIMMYT were tested along with four local checks in wet season of 2003, and in dry season 2004. Ten outstanding breeding lines, including three QPMs were selected for further testing in advanced yield trial at CARDI, Kampong Cham, Kandal and Pailin for two seasons and two years. As the result, two well adapted breeding lines, namely COTAXTLA-S0031 and S-99TLWQ-HG-AB exhibited the most preferred by the farmers with outyielding to their own varieties of 5% to 7%, were recommended to farmers under the names of **Loeung Mongkul** for COTAX-TLA-S0031 and **Sar Chey** for S-99TLWQ-HG-AB.

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Introduction

The introduction of maize in Cambodia is possibly associated with the visits of European missionaries to the country in late 17th and 18th century. It quickly adopted by the Cambodian farmers and becomes one of the most important food crops in the country. Presently, maize is ranking second after rice and is cultivated in a wide range of production environments stretching across the country, from upper to lower Mekong delta and from upland to lowland fields. However, its production concentrates mainly in Pailin, Battambang, Kampong Cham and Kandal (MAFF, 2007). Its production systems vary greatly depending on various factors including crop growing environment, cropping patterns and socio-economic conditions of the farmers. It is grown as a single crop, as an intercrop or mixed crop with others, or in the backyard of the farmer house. In the areas along the river delta of Mekong and Basac, maize is grown in the late dry season just before the onset of rain. The planting time is considerably critical as the crop should be harvested before the arrival of the flood water to the field. In these areas, the crop is generally planted in March to April and harvested in August or September. The farmers can also plant another crop when the flood water completely recedes from the field or at around January. However, in the upland regions of the country, maize production starts either late dry season or in the early wet season depending on the locations. In Pailin, the northwest region of the country, farmers do plant as early as February, but in Kampong Cham, at about the central region of the country, farmers plant as late as June and July. In some places, despite it is not common; farmers do also irrigate the crop especially when the demand is high.

In Cambodia, maize has been traditionally grown for food and to a lesser extent for feed. It is quite common and popular that maize is eaten fresh as boiled when it is still in the early dough stage. For this case, glutinous maize is mostly preferred. Some time, maize is also cooked with rice as staple food especially when the harvest of rice is not sufficient. In addition, maize is also used to prepare several kinds of dessert. However, with the recent expansion of country animal production systems plus the growing demand in the international markets, the shift from food to feed maize has been apparently observed. Consequently, the demand for feed maize has been rapidly rising for the last nine years

(1997-2005, Table 1) leading to a vast expansion of maize production especially in the northwest region of the country (MAFF, 2006, Nou Keosothea, 2005). This rising demand apparently will continue for at least for another 20 years. As projected by Pingali and Pandey (2001), the global demand on maize will be at least doubling in 2020 compared to 1995 but this will vary by regions (Table 2). According to this projection, demand from developing country will grow to about 80 percent from that in 1995. As Cambodia is situated within this group where the demand will rise dramatically, it poses an urgent challenge for the Cambodian maize improvement program to catch up with this growing demand.

Table 1. Cambodia maize production statistics, 1997-2005 (MAFF, 2006)

Year	Total maize production		
	Area ('000 ha)	Production ('000 t)	Yield (t / ha)
1997	49.4	42.4	0.9
1998	44.9	48.5	1.1
1999	59.8	95.3	1.6
2000	71.5	156.9	2.2
2001	80.2	185.6	2.3
2002	80.5	148.9	1.8
2003	93.4	314.6	3.4
2004	91.2	256.7	2.8
2005	90.7	247.8	2.7

Table 2. Maize demand projections, 1995-2020 (Pingali and Pandey, 2001)

Region	Demand		
	1995	*2020*	% change
Global	558	837	50
Developing world	282	504	79
East and Southeast Asia	150	280	46
South Asia	12	23	92
Sub-Saharan Africa	27	52	93
Latin America	76	123	62
West Asia/North Africa	16	26	63

At the country level, a critical attention needs to be tackled. However, at the current situation, Cambodia is still lacking of most improved technologies available elsewhere. One of that is the absent of appropriate varieties for high yielding and with market demanded quality. Due to this reason and because of high marketing demand, majority of maize producing farmers are cultivating varieties developed in the other countries. Hybrid seeds of some commercial varieties popular in Thailand and Vietnam are widely distributed in the country. Production of hybrid maize has been rising rapidly in the country primarily in the north-western region closed to the border with Thailand. On the other hand, along with the spreading of hybrid seeds, new problems have occurred. First, along with very expensive of imported hybrid seeds, Cambodian maize growers are generally small scale and subsistence, and are highly dependent on money borrowed from big moneylenders in the village. Unfortunately, those are not formal credit provider organization whose interest rates are very high, from 5 to 10 percent per month (Nou Keosothea, 2005). Due to this reason, preference for open pollinated varieties over the hybrid ones, as they can save their own seed for sowing next planting seasons, is overwhelming. Second, as varieties have been developed in different growing environments, different level of management practices and to some extent different socioeconomic situations in the other countries, they are not always adapted well to the local growing conditions of the country. This consequently resulted in poorer yield, poorer quality and in many occasions with highly present of many seedborn diseases. The problem further deepened especially when no proper testing had been conducted before sensible recommendations were made. Disputes between local growers and foreign traders frequently broke up due to the inferior marketing quality of maize kernels produced by the Cambodian farmers. Another problem that often happened is the seed quality. As hybrid seed distributed in the country usually come from direct contact between the growers and the crossed border seed dealers, it is not always under any seed importation regulations. Therefore, in most of the time, they are of poor quality with poor gemination, purity and infected by some harmful pests.

Realizing the problems and in respond to the challenge ahead, in mid 2003, the Plant Breeding Department of the Cambodian Agricultural Research and Development Institute (CARDI) under funding support from the Cambodian Agricultural Research Fund (CARF) conducted a number of experiments throughout the country to identify broad adapted high yielding and high quality open pollinated maize varieties for their release to farmers in Cambodia.

Materials and methods

Series of trials and experimental design

A routine four types of trial using by the breeding program in selecting released crop varieties (Men Sarom *et al*., 2000 & 2001) have been used. First, all 70 introduced breeding lines (further are referred as genotype) from CIMMYT were evaluated in observational yield trial (OYT) with none replication in wet season at two sites. A good performance of genotypes then challenged to preliminary yield trial (PYT) with two replications for two seasons for selection of the best ten genotypes testing further in advanced yield trial (AYT) with three replications for three seasons. Plot size of OYT, PYT and AYT was 1.5 m x 5.0 m. Both PYT and AYT at each location and year were arranged in randomized complete block design. Promising genotypes identified from AYTs were tested before their release in farmer's field with farmer's management. This type of trial called pre-on-farm adaptive trial (Pre-OFAT) with no replication and plot size was 7.5 m x 20 m.

There were 10 sets of AYT conducted in the Cambodian Agricultural Research and Development Institute (CA), Kandal (KD), Pailin (PL), and Kampong Cham (KC) in two seasons for two years (Table 3). Experiment at KC in dry season (DS) 2004 was failed due to drought after crop establishment and at PL in dry season (DS) 2005 was also failed due to damage by wild pig. The two failed experiments were not included in the analysis.

Table 3. Location, season and year of advanced yield trial

Location	Year 2004		Year 2005	
	Dry season	Wet season	Dry season	Wet season
CARDI	1	1	1	1
Kandal (CA)	1		1	
Kampong Cham (KC)	1 (failed)			1
Pailin (PL)	1		1 (failed)	

Genotypes used

Seventy open pollinated genotypes introduced from CIMMYT were evaluated in OYT (Table 4). Among the 70 genotypes, 59 genotypes were normal maize (15 genotypes were yellow color kernel type and 44 were white color kernel type) and 11 were quality protein maize (QPM). In 1986, CIMMYT scientists were successful in transferring opaque-2 mutant maize found in 1963 as it has a nearly twice as nutritious proteins as those found in cultivated maize. Since that they called transferred opaque-2 maize as QPM and those of not transferred as normal maize (Brown *et al*., 1988). The QPM composed of 10 white kernel type and one yellow kernel type. Twenty eight genotypes selected from OYT (No. 1-28 in Table 4) were tested in PYT in dry season (Jan. – Jun. 2004), from that 18 genotypes (No. 1-18 in Table 4) were repeated again in PYT wet season (Jul. – Dec. 2004). Selection of genotypes from OYT and PYT were base on kernel yield and other agronomic traits (data are not shown). Ten better genotypes (No. 1-10 in Table 4) composed of four QPM (one is yellow kernel), four yellow kernel genotypes and two white kernel genotypes, then were tested in AYT along with two open pollinated checks (Composit 1 and Supper sweet corn, both from Kbal Koh station). Four promising genotypes with two QPM selected from AYT were tested in Pre-OFAT. Management and results of AYT and Pre-OFAT are shown and discussed in the following sections.

Table 4. Genotypes, kernel type (Y=yellow, W=white) and quality protein maize (QPM)[A] used in experiments

No	Genotype	Discription	No	Genotype	Discription
1	COTAXTLA-S0031	Y	36	DTPWC8F175-1-1-B	W
2	S-99TLWQ-HG-AB	W, QPM	37	DTPWC8F204-2-B	W
3	S-00TLWQ-B	W,QPM	38	DTPWC8F224-2-B	W
4	POZA-RICA S9627	Y	39	DTPWC8F231-2-B	W
5	S-99TLYQ-AB	Y,QPM	40	DTPWC8F317-1-1-B	W
6	AGUA-FRIA S0031	Y	41	DTPWC8F324-1-1-B	W
7	S-0128	Y	42	DTPWC8F353-1-1-B	W
8	S-99TLW-BN SEQ(1)	W,QPM	43	G16BNSEQC0F118-1-1-4-2-B-B-B-B	W,QPM
9	AGUA-FRIA S0030	W	44	G16BNSEQC0F118-1-2-1-2-B-B-B-B	W,QPM
10	AGROSS S0030	W	45	G16SeqC1-15-2-1-2-2-2-B-B-B-B-B	W
11	DTPWC8F31-1-1-B	W	46	SOEC6F74-1-4-1-1-1-B-B-B-B-B-B	W
12	DTPWC9-F5-4-1-1//CML-449	W	47	DTPWC8f324-1-1-1#-B	W
13	DTPWC9-F55-1-1-1//CML-449	W	48	DTPWC8F61-1-B	W
14	DTPWC9-F67-2-2-1//CML-449	W	49	DTPWC8F76-1-B	W
15	DTPWC9-F70-4-4-1//CML-449	W	50	DTPWC8F31-1-2-1-#-B	W
16	DTPWC9-F104-5-4-1//CML-449	W	51	DTPWC8F184-1-B	W
17	DTPWC9-F115-1-2-1//CML-449	W	52	DTPWC8F107-2-B	W
18	DTPWC9-F120-3-3-1//CML-449	W	53	G16BNSEQC0F118-1-1-4-1-B-B-B-B	W,QPM
19	DTPWC9-F131-1-3-1//CML-449	W	54	G16BNSEQC0F118-1-1-3-1-B-B-B-B	W,QPM
20	DTPYC9-F46-1-2-1//CML-451	Y	55	DTPWC8F321-1-B	W
21	DTPYC9-F46-1-6-1//CML-451	Y	56	G16BNSEQC0F118-1-1-4-5-B-B-B-B	W,QPM
22	DTPYC9-F463-4-1//CML-451	Y	57	DTPWC8F255-1-B	W
23	DTPYC9-F46-3-5-1//CML-451	Y	58	DTPWC8F204-1-B	W
24	DTPW C9	W	59	DTPWC8F317-1-1-1-#-B	W
25	DTPY C9	Y	60	DTPWC8F100-1-2-B	W
26	G16BNSEQ. C3	W,QPM	61	DTPWC8F126-1-B	W
27	G18SEQ C5	W,QPM	62	DTPWC8F31-1-B	W
28	SPE C8	W	63	DTPWC8F128-1-B	W
29	DTPWC8F31-1-3-1-B	W	64	DTPWC8F266-1-1-1-#-B	W
30	DTPWC8F266-1-1-1-B	W	65	DTPYC9-F69-3-6-1//CML-451	Y
31	DTPWC8F347-1-3-1-B	W	66	DTPYC9-F74-1-1-1//CML-451	Y
32	DTPWC8F100-1-2-B	W	67	DTPYC9-F86-2-2-1//CML-451	Y
33	DTPWC8F76-1-1-B	W	68	DTPYC9-F103-5-1-1//CML-451	Y
34	DTPWC8F107-2-B	W	69	DTPYC9-F134-2-3-1//CML-451	Y
35	DTPWC8F128-1-B	W	70	DTPYC9-F43-5-1-1//CML-451	Y

[A] QPM is known as "opaque-2 maize" because it has a chalky appearance due to the presence of high levels of lysine and tryptophan and amino acids. Traditional maize varieties are generally lower in those.

Cultural practice

In AYTs, soils were ploughed two times and harrowed after second plough. Raised beds were made by hand with 40 cm width and 25-30 cm height. Two seeds were placed in 2-3 cm depth-hill by hand in mid bed with 75 cm between rows and 25 cm within row. Pruning was done to one plant per hill at 10-15 days after planting (DAP). Missing hills were found in few plots in each experiment and replanted by pruned plants during the pruning time. Crops were irrigated in dry season and when there was a dry period in wet season. Weeds were controlled by hand for two to three times depend upon on the needs. No pesticides or herbicides were used.

The fields were fertilized with 100:80:60 kg/ha of $N:P_2O_5:K_2O$. Nitrogen was applied as urea (46% N) and diamonium phosphate (18% N) on three times (30% as basal, 30% at 20DAP and 40% at 40DAP), while P_2O_5 and K_2O were applied once as a basal application of diamonium phosphate (46% P) and of potassium chloride (60% K), respectively.

Pre-OFAT was managed by farmers but they have to follow protocol with 10 rows wide and 20 m long. Most farmers planted with 75 cm between rows and 25 – 35 cm within row. Soils were ploughed two times and harrowing was done in some fields depend upon farmers. A few farmers applied chemical fertilizer in a very small amount. Weeds were controlled by hand and no pesticides were used.

Data Measurement

Days-to-male flowering (DTMF) was measured as a time taken from seeding to 50% pollens shed of the all plants in plot. Days-to-female flowering (DTFF) was recorded from planting to 50% of the plants in the plot have silks two to three centimeters long. At maturity, plant and ear heights were measured from soil surface to the point where the tassel starts to branch and to the node bearing the upper most ears, respectively. Kernel yield was calculated on a dry weight basis harvested from the whole plot.

Analysis of variance

Three types of analysis were performed for kernel yield of eight environments of AYT. First, a combined analysis was performed to see the effects of year (Y), location (L) and genotype (G) and their interactions of 12 genotypes tested in dry season at two sites (CARDI and Kandal) for two years [1]. Second, a combined analysis was performed to see the effects of year, genotype and their interaction tested at CARDI in wet season for two years [2]. The last analysis was performed to see the environment (E = location -year) and genotype and their interaction as a whole [3]. The G x E analysis also was performed for the days-to-male and female flowering, plant height and ear height of the 12 genotypes (data are not shown). The three types of analysis of variance were conducted using IRRISTAT4.04. Also the components of variance (σ^2) for kernel yield were estimated using REML 3.6 (Residual Maximum Likelihood).

$$y_{ijkl} = \mu + y_k + l_j + (ly)_{jk} + (r/ly)_{ijk} + g_i + (gl)_{ij} + (gy)_{ik} + (gly)_{ijk} + \varepsilon_{ijkl}$$

where μ is the grand mean, y_k, l_j and $(ly)_{jk}$, $(r/ly)_{ljk}$, g_i, $(gy)_{ik}$, $(gl)_{ij}$, $(gly)_{ijk}$ and ε_{ijkl} are the random effects of year (Y), location (L) and location-by-year (LxY), respectively, replicates, genotype (G) and genotype-by-year (GxY), genotype-by-location (GxL), genotype-by-location-by-year (GxLxY) and residuals, respectively.

$$y_{ijkl} = \mu + y_k + (r/y)_{lk} + g_i + (gy)_{ik} + \varepsilon_{ijk}$$

where μ is the grand mean, y_k, $(r/y)_{jk}$, g_i, $(gy)_{ik}$ and ε_{jkl} are the random effects of year (Y), replicates, genotype (G) and genotype-by-year (GxY) and residuals, respectively.

$$y_{ijkl} = \mu + e_m + (r/e)_{jm} + g_i + (ge)_{im} + \varepsilon_{ijm}$$

where μ is the grand mean, e_m, $(r/e)_{jm}$, g_i, $(ge)_{im}$ and ε_{ijm} are the random effects of environment (E), replicates, genotype (G) and genotype-by-environment (GxE), and residuals, respectively.

Stability analysis was performed for mean kernel yields of genotypes across eight environments to see the consistency of these genotypes by ranking of kernel yields accordingly from the highest to the lowest in each environment.

For Pre-OFAT, mean over trials and its standard deviation (SD) was calculated with kernel yield advantage of tested genotypes over farmer's varieties. Farmer's first preference for all genotypes (including farmer's variety) is also provided.

Results

There were effects of Y, L and G and their interactions (P<0.01) for kernel yield of 12 genotypes tested in dry season at two locations (CARDI and Kandal) and for two years with L had a greatest effect (σ^2 = 3.7) and was 7.7 times of that genotype component (Table 5a). However, there was only significant (P<0.01) and slightly greater effect of genotype (σ^2 = 0.76) than the year component when combined analysis was performed for wet season for two years for kernel yield of genotypes tested in CARDI (Table 5b). When Location-year experiment was considered as environment (E) then there were effects of E and G and also their interaction (G x E) (P<0.01) (Table 5c). The environment component was 5.4 and 4.5 times of those genotype and genotype-by-environment components, respectively. The results, in general, indicate instability of tested genotypes in kernel yield across environments.

Table 5. Components of variance (σ^2) and standard error (SE), and level of significance for kernel yield of 12 genotypes tested from 2004-2005

Year (Y)	Location (L)/E	Y x L	Genotype (G)	G x Y	G x L/E	G x L x Y
a) Combined across CARDI and Kandal over years for dry season						
0.50±0.18**	3.70±0.13**	1.25±0.18**	0.48±0.21**	0.28±0.13**	0.00±0.12ns	0.87±0.39**
b) Combined across years for CARDI in wet season						
0.72±0.69ns			0.76±0.26**	0.00±0.28ns		
c) Combined across all location-year (environment) experiments						
	3.51±1.39**		0.65±0.23**		0.78±0.18**	

** Significant at P<0.01, ns = Not significant at P<0.05.

Table 6 shows kernel yield of tested genotypes at each environments and their mean across eight environments, and environmental mean across tested genotypes. In general, environmental kernel yield in wet season (average over three environments = 6.38 t/ha) was higher than in the dry season (average over five environments = 4.61 t/ha). At CARDI, crops grown in both dry seasons on Prateah Lang soil with low fertility (White *et al.*, 1997), therefore, kernel yields were the lowest among the eight environments. However, in wet season, crops grown on upland areas in CARDI, therefore, kernel yields were intermediate compared to KC05WS.

Table 6. Kernel yield of tested genotypes, and genotypic mean and environmental mean kernel yield over eight environments

Nº	Genotype	CA04DS	KD04DS	PL04DS	CA04WS	KD05DS	CA05DS	KC05WS	CA05WS
1	S-99TLYQ-AB	3.66	8.35	4.73	6.68	5.12	2.13	8.63	4.32
2	COTAXTLA-S0031	4.19	7.88	7.14	8.01	5.45	3.70	10.90	5.18
3	AGUA-FRIA-S0031	4.00	7.72	6.88	6.48	5.31	3.30	10.83	5.28
4	POZA-RICA S9627	2.55	8.95	4.76	4.52	4.55	3.33	8.87	4.99
5	S-0128	2.93	8.18	5.00	5.25	4.46	3.50	8.47	3.74
6	S-99TLWQ-HG-AB	4.42	8.66	4.76	6.68	4.58	2.53	8.20	4.32
7	S-00TLWQ-B	3.12	9.12	4.76	7.33	5.13	2.43	10.50	5.25
8	S-99TLW-BN-EQ(1)	3.33	7.78	5.57	7.10	6.19	3.60	10.07	6.81
9	AGUA-RRIA S0030	3.76	7.32	4.94	6.82	5.85	3.60	8.23	5.02
10	ACROSS-S0030	3.06	8.26	4.83	6.93	5.27	2.97	8.03	4.88
11	Composite (loc.1)	1.25	3.05	1.97	3.33	2.15	2.00	3.90	2.41
12	Super sweet corn (loc.2)	2.68	3.18	3.91	4.17	1.77	1.23	4.73	2.71
Mean		3.25	7.37	4.94	6.11	4.65	2.86	8.45	4.58

Days-to-male (DMF) and female (DFF), plant height (PH) and ear height (EH) of eight environments are shown in Table 7. The four variables were significant differed among the environments. In general, crop grown at CARDI flowered later and had shorter plant than growing at Pailin, Kandal and Kampong Cham, because CARDI's soil was less fertile than the other three locations. Crop grown on fertile soils (KC05WS and KD04DS) enhanced flowering for about 11 days compared to poor soils (CA04DS and CA05WS) and this enhancement positively related to kernel yield (Fig. 1, $R^2 = 0.79$**).

Table 7. Environmental mean values of days-to-male and -female flowering, plant and ear height across 12 genotypes

Environment (E)	Day to male flowering (day)	Day to female flowering (day)	Plant height (cm)	Ear height (cm)
CA04DS	55	59	185	86
KD04DS	51	53	221	103
PL04DS	56	57	230	120
CA04WS	55	58	165	72
KD05DS	49	50	221	107
CA05DS	57	60	145	51
KC05WS	47	49	202	105
CA05WS	56	57	152	77
Mean	53	55	190	90
5%LSD	1**	1**	11**	10**
G x E	**	**	ns	ns

CA04DS = CARDI dry season 2004, KD04DS = Kandal dry season 2004, PL04DS = Pailin dry season 2004, CA04WS = CARDI wet season 2004, KD05DS = Kandal dry season 2005, CA05DS = CARDI dry season 2005, KC05WS = Kampong Cham wet season 2005, CA05WS = CARDI wet season 2005.
** Significant at $P<0.01$, ns = Not significant at $P<0.05$.

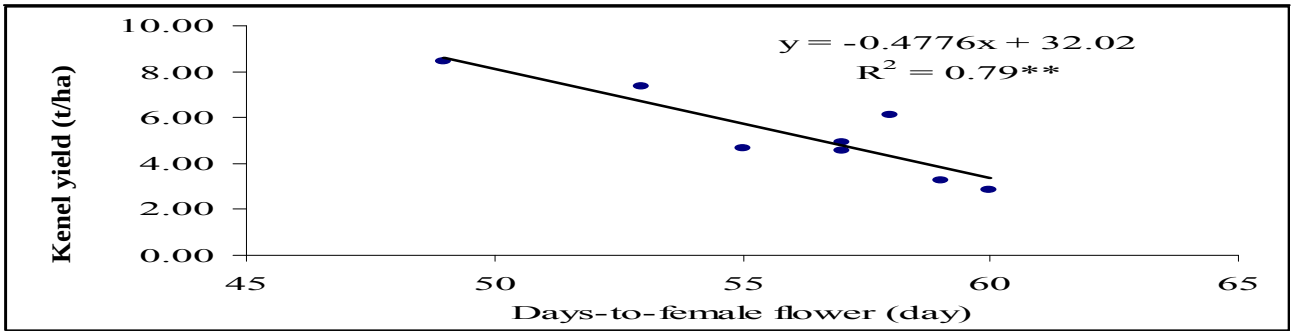

Figure1. Relationship between environmental mean days-to-female flowering and kernel yield.

There was significant difference among the genotypes for DMF, DFF, PH and EH (P<0.01) but this difference was small; being six days for DMF, five days for DFF, 35 cm for PH and 24 cm for EH (data not shown). In general, kernel yield was slightly associated with plant height with taller genotype yielded higher (Fig. 2, R^2 = 0.47*).

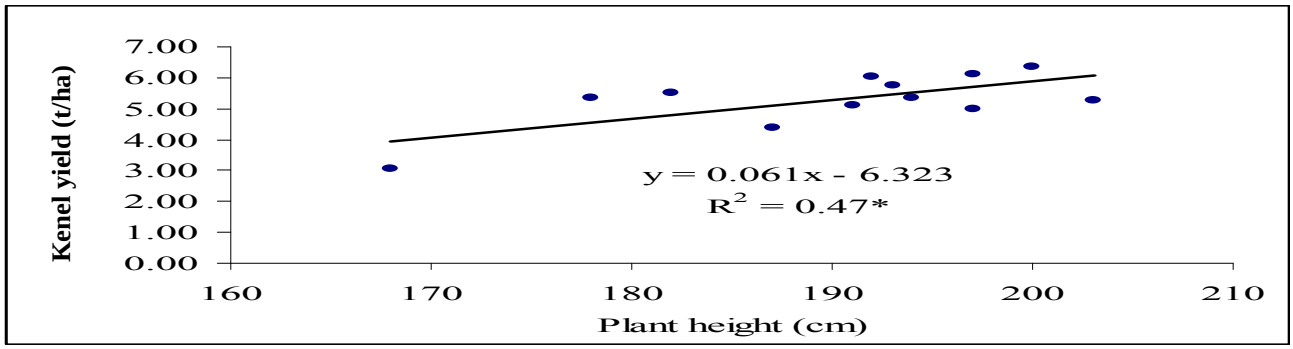

Figure2. Relationship between genotypic mean plant height and kernel yield.

Since there was an effect of G x E interaction, the stability analysis was performed by ranking genotypes base on kernel yield for all environments (Table 8). Two genotypes ranked more consistently across environments with one (COTAXLA-S0031) had the highest kernel yield (6.56 t/ha) and another (S-99TLWQ-HG-AB) had intermediate kernel yield (5.52 t/ha). COTAXLA-S0031 ranked more consistently higher across environments (2.0±1.4). In contrast, Composite (Check 1) yielded the lowest, but ranked highly consistent across environments (11.8±0.5). There were some genotypes ranked good in better environments and intermediate in the others. Genotype S-00TLWQ-B yielded the highest in KD04DS and 3rd in CA04WS and KC05WS, but intermediate in other environments. Similar trend was also observed for POZA-RICA S96127.

Table 8. Mean kernel yield (MKY) and ranking of genotypes and their mean across eight environments

Nº	Genotype	MKY	CA04DS	KD04DS	PL04DS	CA04WS	KD05DS	CA05DS	KC05WS	CA05WS	Mean ± SD
2	COTAXTLA-S0031	6.56	1	4	1	1	3	1	1	4	2.0±1.4
8	S-99TLW-BN-EQ(1)	6.31	6	8	3	3	1	2	4	1	3.5±2.4
3	AGUA-FRIA-S0031	6.22	2	9	2	8	4	6	2	2	4.4±2.9
7	S-00TLWQ-B	5.96	7	1	8	2	6	9	3	3	4.9±3.0
9	AGUA-FRIA S0030	5.69	3	10	5	5	2	3	8	5	5.1±2.7
10	ACROSS-S0030	5.53	8	3	6	4	5	7	10	7	6.3±2.3
6	S-99TLWQ-HG-AB	5.52	5	5	7	6	8	8	9	8	7.0±1.5
1	S-99TLYQ-AB	5.45	4	7	10	7	7	10	6	9	7.5±2.1
4	POZA-RICA S9627	5.31	11	2	9	11	9	5	5	6	7.3±3.2
5	S-0128	5.19	9	6	4	9	10	4	7	10	7.4±2.5
11	Composite (loc.1)	2.51	12	12	12	12	11	11	12	12	11.8±0.5
12	Super sweet corn (loc.2)	3.05	10	11	11	10	12	12	11	11	11.0±0.8
Mean kernel yeild (t/ha)		5.27	3.25	7.37	4.94	6.11	4.65	2.86	8.45	4.58	
SD		0.89	0.86	2.06	1.32	1.27	1.11	0.79	1.68	0.97	
5% LSD		0.55									

CA04DS = CARDI dry season 2004, KD04DS = Kandal dry season 2004, PL04DS = Pailin dry season 2004, CA04WS = CARDI wet season 2004, KD05DS = Kandal dry season 2005, CA05DS = CARDI dry season 2005, KC05WS = Kampong Cham wet season 2005, CA05WS = CARDI wet season 2005.
** Significant at P<0.01.

Discussion

One of the main reasons for decreasing area of hybrid maize in recent years, being 73,000 ha in 2003 to 67,000 ha in 2005 (Sakhan *et al*., 2006; MAFF, 2006) was due to high price of hybrid seeds or impurity of hybrid seeds. Therefore, many farmers preferred open pollinated maize with high yielding and quality so they can keep the seeds from season to season with high harvested profit (unpublished survey data). On average, ten out of initial 70 open pollinated genotypes yielded higher than the average two check varieties of 2.41 t/ha to 3.78 t/ha. There were year, location, environment and their interaction effects for kernel yield indicating that for selecting maize genotypes there is a need to test across locations and over years.

However, result obtained from the stability analysis shows that there were some genotypes yielded consistent in ranking across the environments. Among the normal maize, COTAXTLA-S0031 yielded the highest and performed the most consistent across eight tested environments (6.56 t/ha, 2.0±1.4). This genotype flowered earlier in both male (51 days) and female (53 days) with intermediate EH (87 cm), but tall plant type (200 cm). COTAXTLA-S0031 is normal open pollinated maize with semi-leaf-upright-plant type and matured in 105 days. Number of ear-row varied from 12 to 14. This genotype has yellow semi-flint kernel. An approximate 1000 kernel weight was 300g. S-99TLWQ-HG-AB was also performed the most consistent with intermediate kernel yield (5.52 t/ha, 7.0±1.5) among the QPM genotypes. Days-to-male and female flowering was 55 days and 58 days, respectively, and matured in 108 days. The plant type is semi-leaf-upright and tall (191 cm) with intermediate EH (91 cm). Kernel is white and weighed 266 g for 1000 kernels. These two genotypes have been identified as outstanding genotypes. Two other genotypes (POZA-RICA S9627, normal maize, and S-00TLWQ-B, QPM) have been also identified as high yielding genotypes when grow on fertile soil (kernel yield was 8.95 t/ha at KD04DS and 8.87 t/ha at KC05WS for POZA-RICA S9627; and 9.12 t/ha at KD04DS and 10.50 t/ha at KC05WS for S-00TLWQ-B) with strong stem and good ear type.

The four promising genotypes (COTAXTLA-S0031, S-99TLWQ-HG-AB, POZA-RICA S9627 and S-00TLWQ-B) have been selected and tested along with farmer's popular variety in the farmer's field conditions at 30 sites in Pailin in 2005 wet season and 2006 dry season. Results of kernel yield of all genotypes including farmer's popular varieties (all were Hybrid-888) obtained from 27 sites (three were failed due to damage by rabbits and drought) are shown in Table 9. All promising genotypes, in average, yielded little higher than the Hybrid-888 by 2% to 7%. However, ten farmers given the highest preference to COTAXTLA-S0031 followed by S-99TLWQ-HG-AB (8 farmers) as they had a good kernel and open pollinated type so they can keep seeds from season to season.

Table 9. Yield (t/ha) of 27 pre-on-farm trials, conducted in Pailin in wet season 2005 and dry season 2006

Genotype	Kernel yield ± SD	Yield Adv. (%)	Farmer first preference
COTAXTLA-S0031	10.19±1.74	7	10
S-99TLWQ-HG-AB	9.97±1.78	5	8
POZA-RICA S9627	9.94±1.98	4	6
S-00TLWQ-B	9.79±1.89	2	4
Farmer's variety (Hybrid-888)	9.52±1.35		2

Conclusion

There were year, location, genotype and their interaction effects for kernel yield even 12 genotypes were used. Therefore, plant breeder should conduct the experiments across years and locations in order to select the best for specific or broad adaptation. However, among the tested genotypes, two high yielding and good quality genotypes were broadly adapted across tested environments and in the farmer's field management. With farmer's management, a normal maize with white kernel type (COTAXTLA-S0031) yielded 7% and one QPM genotype with white kernel type (S-99TLWQ-HG-AB) yielded 5% higher than the farmer's variety (9.52 t/ha), therefore, they were released as Loeung Mongkul for COTAXTLA-S0031 and Sar Chey for S-99TLWQ-HG-AB for farmer use.

Acknowledgement

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MEETING

THE FIRST ANNUAL MEETING OF THE EDITORIAL BOARD OF THE CAMBODIAN JOURNAL OF AGRICULTURE

The first annual meeting of the editorial board of the Cambodian Journal of Agriculture (CJA) was conducted on 27 July 2007 at the Cambodian Agricultural Research and Development Institute (CARDI). The meeting was presided over by Dr. Men Srom, Director of CARDI and Editor of CJA and attended by members of the editorial board in country.

The main objective of the meeting is to find effective solution to strengthen the Cambodian Journal of Agriculture, to get more support from donors, research community and publics. It was agreeable that all board members, national and international, need to deliver information on CJA to their colleagues, friends, and research fellows and loby for their contribution to the journal. The meeting also discussed about a possibility to conduct a CJA assembly at the end of the year and for every 3-5 years, provided fund can be found.

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សេចក្តីជូនដំណឹង

វិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា មានកិត្តិយសសូមជម្រាបជូនដំណឹងដល់ លោក លោកស្រី អ្នកនាងកញ្ញា ជាអ្នកស្រាវជ្រាវទាំងអស់ ឱ្យបានជ្រាបថា ដោយយល់ឃើញពីគុណសម្បត្តិ និងសារប្រយោជន៍នៃទស្សនាវដ្តីកសិកម្មកម្ពុជា ក្នុងការផ្តល់លទ្ធភាពជូនអ្នកស្រាវជ្រាវខ្មែរ ទាំងឡាយឱ្យមានឱកាសបង្កើនសមត្ថភាពស្រាវជ្រាវរបស់ខ្លួនតាមរយៈការសរសេរ ការបកស្រាយ និងចូលរួមពិភាក្សានូវរាល់គំហើញវិទ្យាសាស្ត្រផ្សេងៗ ដែលជាកត្តាចាំបាច់មិនអាចខ្វះបានសម្រាប់អ្នកស្រាវជ្រាវ ដើម្បីជាការពង្រឹងវិស័យស្រាវជ្រាវជាតិ ហើយក៏ដើម្បីជាកិត្តិយសដ៏ខ្ពង់ខ្ពស់សម្រាប់ប្រទេសជាតិយើងដែរនោះ វិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា បានខិតខំព្យាយាមជម្រុញឱ្យមានការបង្កើតឡើងនូវទស្សនាវដ្តីកសិកម្មកម្ពុជានេះ និងធ្វើយ៉ាងណាឱ្យទស្សនាវដ្តីនេះបានរស់រានជីវិតឡើងវិញក្រោយពីត្រូវអាក់ខានមួយរយៈ។

នាពេលបច្ចុប្បន្ន ក្រោយពីមានការបង្កើតឡើងជាថ្មីនូវក្រុមប្រឹក្សាពិនិត្យ (Editorial Board) របស់ទស្សនាវដ្តី ដែលមានការចូលរួមពីអង្គភាពពាក់ព័ន្ធជាច្រើន វិទ្យាស្ថានបាននិងកំពុងរៀបចំដំណើរការបោះពុម្ពទស្សនាវដ្តីកសិកម្មកម្ពុជា (Cambodian Journal of Agriculture) នេះឱ្យមានជាប្រក្រតីភាពឡើងវិញ ដូចដែលវិទ្យាស្ថានធ្លាប់បានធ្វើការរៀបចំ និងបោះពុម្ពផ្សាយជាហូរហែរកន្លងមកដើម្បីជាការផ្សព្វផ្សាយទាំងក្នុង និងក្រៅប្រទេស។

អាស្រ័យហេតុនេះដើម្បីឱ្យទស្សនាវដ្តីនេះអាចមានសកម្មភាព និងដំណើរការទៅមុខបាន វិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា ក៏ដូចជាក្រុមប្រឹក្សាពិនិត្យនៃទស្សនាវដ្តីកសិកម្មកម្ពុជា មានក្តីសង្ឃឹមយ៉ាងមុតមាំ និងជឿជាក់ចំពោះការចូលរួមគាំទ្រពីសំណាក់ លោក លោកស្រី អ្នកនាង កញ្ញា ទាំងឡាយដែលមានបំណងចង់បង្ហាញពីការរកឃើញវិទ្យាសាស្ត្រផ្សេងៗ ក៏ដូចជាបទពិសោធន៍ល្អៗជូនដល់អ្នកស្រាវជ្រាវដ៏ទៃៗទៀត និងក៏ដូចជាចង់ជួយពង្រឹងវិស័យស្រាវជ្រាវជាតិយើងផងដែរក្នុងការផ្តល់នូវអត្ថបទស្រាវជ្រាវផ្សេងៗសម្រាប់ជាការបោះពុម្ពក្នុងទស្សនាវដ្តី។

សូមអរគុណ

ព័ត៌មានបន្ថែមសូមទំនាក់ទំនង:

វិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា

ផ្លូវជាតិលេខ ៣ សង្កាត់ប្រទេះឡាង ខណ្ឌដង្កោ រាជធានីភ្នំពេញ

ប្រអប់សំបុត្រលេខ ០១ ភ្នំពេញ

ទូរស័ព្ទលេខ: (៨៥៥-២៣) ២១៩ ៦៥២ / ០១១ ៨១៨ ៧៩៨

ទូរសារលេខ: (៨៥៥-២៣) ២១៩ ៨០០

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ការណែនាំសម្រាប់អ្នកនិពន្ធ

តម្រូវការទូទៅ

ការបោះពុម្ពផ្សាយនៅក្នុងទស្សនាវដ្តីកសិកម្មកម្ពុជា (CJA) អាចជារបាយការណ៍ដើមនៃលទ្ធផលស្រាវជ្រាវ (អត្ថបទ ឬ កំណត់ត្រាខ្លីៗ) អាចជាលិខិតដែលបញ្ជូនទៅអ្នកត្រួតពិនិត្យ ជាការផ្សព្វផ្សាយពាណិជ្ជកម្ម ឬការប្រកាសនូវដំណឹងនានា។ កំណត់ត្រាស្រាវជ្រាវមិនត្រូវសរសេរលើសពី ២ ទំព័រ ទេ ឯការផ្សព្វផ្សាយវិញក៏មិនត្រូវឱ្យលើសពីកន្លះទំព័រដែរ។

តួអត្ថបទ ឬកំណត់ត្រា

អត្ថបទដែលបានរៀបចំត្រូវផ្ញើរមកអ្នកពិនិត្យដោយប្រព័ន្ធអេឡិចត្រូនិក (តាមរយៈទូរអក្សរ ឬ តាមរយៈថាស) ក្នុងនោះត្រូវមាន តារាង និងក្រាហ្វិក ឯកសារយោង ចំណងជើងតារាង និងចំណងជើងក្រាហ្វិក។ រូបភាពត្រូវតែជារូបដើម ឬថតចំលង (Scan) ឱ្យច្បាស់ដើម្បីធានានូវគុណភាពរបស់រូបសម្រាប់ទស្សនាវដ្តី។ អត្ថបទដែលផ្ញើរមកកាន់ទស្សនាវដ្តីកសិកម្មកម្ពុជា (CJA) អាចជាភាសាអង់គ្លេស ឬភាសាខ្មែរ។ ក្នុងករណីដែលអត្ថបទជាភាសាអង់គ្លេសត្រូវប្រើប្រភេទអក្សរ Time New Roman ដោយមានការបកប្រែជាភាសាខ្មែរនូវចំណងជើង និងសង្ខេបដោយប្រើប្រភេទអក្សរ Limon។ ចំពោះអត្ថបទជាភាសាខ្មែរត្រូវប្រើប្រភេទអក្សរ Limon ដោយមានការបកប្រែជាភាសាអង់គ្លេសនូវចំណងជើង និងសេចក្តីសង្ខេបដោយប្រើប្រភេទអក្សរ Times New Roman ។

រចនាសម្ព័ន្ធ

ចំណងជើង : ត្រូវនៅទំព័រទី១ នៃអត្ថបទ ឬ កំណត់ត្រា។ ចំណងជើងត្រូវសរសេរឱ្យបានខ្លី ប៉ុន្តែច្បាស់លាស់ និងឆ្លើយតបទៅនឹងអត្ថបទ។

អ្នកនិពន្ធ : នៅខាងក្រោមចំណងជើង ត្រូវដាក់ឈ្មោះអ្នកនិពន្ធទាំងអស់ដែលពាក់ព័ន្ធក្នុងការងារស្រាវជ្រាវ។ ដកឃ្លាពីឈ្មោះអ្នកនិពន្ធមួយទៅឈ្មោះ អ្នកនិពន្ធមួយដោយប្រើសញ្ញា Comma (,) ហើយឈ្មោះអ្នកនិពន្ធចុងក្រោយគេត្រូវដាក់ឈ្មាប់ " និង " " and " នៅពីមុខ។ ឈ្មោះអ្នកនិពន្ធ/អត្ថបទនានា គួរតែមាននៅក្នុង Footnote នៃទំព័រទី១។ គួររៀបចំជាបញ្ជីនូវឈ្មោះអ្នកនិពន្ធ និងបញ្ជាក់ពីអាស័យដ្ឋាន និងឯកសារពាក់ព័ន្ធផ្សេងៗនៅក្នុងឃ្លាទី១នៃ Footnote ហើយក្នុងឃ្លាទី២ គួរដាក់បញ្ចូលនូវ ប្រភពមូលនិធិ ប្រសិនបើពុំទាន់បានបង្ហាញនៅក្នុងសេចក្តីថ្លែងអំណរគុណ។

សេចក្តីសង្ខេប : អត្ថបទនិមួយៗត្រូវមានសេចក្តីសង្ខេបជាពីរភាសា គឺភាសាខ្មែរ និងភាសាអង់គ្លេស។ សេចក្តីសង្ខេបត្រូវឱ្យខ្លីតែច្បាស់លាស់ហើយត្រូវសរសេរមិនលើសពី ២៥០ ពាក្យ សម្រាប់អត្ថបទ និង ១៥០ ពាក្យ សម្រាប់កំណត់ត្រា។ ត្រូវរៀបរាប់អំពីសនិទានភាព ទិសដៅ វិធីសាស្ត្រ លទ្ធផលគន្លឹះ និងសារៈសំខាន់របស់វា ពិសេសសម្រាប់កសិកម្មកម្ពុជា។ បន្ទាប់ពីរៀបសេចក្តីសង្ខេបត្រូវរៀបចំតាមលំដាប់លំដោយ សេចក្តីផ្តើម ដែលរួមបញ្ចូលនូវការវិភាគទៅលើបណ្ណាល័យសាស្ត្រ ពាក់ព័ន្ធហើយបន្តដោយខ្លីៗ សម្ភារៈ វិធីសាស្ត្រ លទ្ធផល ការពិភាក្សា សេចក្តីសន្និដ្ឋាន (អាស្រ័យលើអ្នកនិពន្ធ) សេចក្តីថ្លែងអំណរគុណ (អាស្រ័យលើអ្នកនិពន្ធ) និងឯកសារយោង។ លទ្ធផល និងការពិភាក្សាអាចបញ្ចូលគ្នា ហើយសេចក្តីសន្និដ្ឋានអាចមាននៅក្នុងផ្នែកពិភាក្សា។

តារាង : តារាងទាំងអស់ត្រូវដាក់លេខរៀង ហើយត្រូវមានចំណងជើង។ Headnote ដែលមានព័ត៌មានផ្សេងៗពាក់ព័ន្ធទៅនឹងតារាងទាំងមូល គួរចាប់ផ្តើមនៅបន្ទាត់ថ្មីមួយ។ តារាងគួររៀបចំទៅតាមទំហំកូឡោនគំរូរបស់ទស្សនាវដ្តី (ទំហំ ៨ ស.ម ទៅ ២១ ស.ម) ហើយចំនួនកូឡោននៅក្នុងតារាងគួរឱ្យមានចំនួនតិច។ ការបំបែកចំណងជើងតូចៗ ពីចំណងជើងកូឡោនមេច្រើនពេកគឺមិនល្អទេ ហើយចំណងជើងវែងពេកក៏គួរជៀសវាងដែរ ដោយប្រើការសរសេរពន្យល់ខ្លីៗជំនួសវិញដែលការសរសេរទាំងនោះមានលក្ខណៈស៊ីគ្នាទៅនឹង Head note។ តួអក្សរទី១ នៅខាងដើមគួរសរសេរជាអក្សរធំ។

និមិត្តសញ្ញា នៃខ្នាតរង្វាស់ផ្សេងៗ គួរដាក់ក្នុងរង្វង់ក្រចកខាងក្រោមចំណងជើងកូឡោន។ បុព្វបទសម្រាប់ឯកតាគួរជ្រើសរើសយ៉ាងណាមិនឱ្យមានចំនួនលេខច្រើនពេក។ ក្នុងករណីមិនអាចជៀសវាងបានគួរដាក់ចំនួននោះដោយមេគុណ ១០ នូវរាល់តំលៃទាំងឡាយក្នុងតារាង។ កំណត់សំគាល់ខាងក្នុងតារាងគួរតែរក្សាទំហំអក្សរឱ្យតូច និងត្រូវរក្សាទុកសម្រាប់ការបរិយាយជាក់លាក់ផ្សេងៗក្នុងកូឡោន។

បន្ទាត់ផ្តេកអាចដាក់ខាងលើ និងខាងក្រោមចំណងជើងក្រឡោន និងនៅខាងក្រោមបង្អស់នៃតារាងតែប៉ុណ្ណោះ។ ចំពោះបន្ទាត់បញ្ឈរវិញមិនគួរប្រើទេ។ រាល់តារាងនិមួយៗត្រូវឆ្លើយតបនៅក្នុងអត្ថបទ ហើយចំណុចសំគាល់តូចមួយនៅក្នុងតែមទំព័រ (Margin) គួរសរសេរបង្ហាញពីទីតាំងពិតប្រាកដរបស់តារាងនៅក្នុងអត្ថបទ។ តារាងខ្លីៗអាចដាក់បញ្ចូលទៅក្នុងអត្ថបទក្នុងលក្ខណៈជាប្រយោគ និងមិនចាំបាច់មានចំណងជើងទេ។ លើកលែងតែក្នុងករណីពិសេសប៉ុណ្ណោះដែលទិន្នន័យអាចត្រូវបានបង្ហាញទាំងក្នុងតារាង និងក្នុងក្រាហ្វិក។ បើពុំនោះទេគួរប្រើក្រាហ្វិកវិញក្នុងករណីចាំបាច់។

ក្រាហ្វិក : ក្រាហ្វិកទាំងឡាយណាដែលមិនល្អ (ឧ. ក្រាហ្វិក ស្ថិតក្នុងទ្រង់ទ្រាយពិបាកអាន/យល់) នឹងត្រូវបញ្ជូនឱ្យយកទៅពិនិត្យដើម្បីកែសម្រួលឡើងវិញ។ ចំពោះអ្នកនិពន្ធដែលមិនអាចរៀបចំជាក្រាហ្វិកផ្សេងៗបាន គួរទំនាក់ទំនងជាមួយអ្នកត្រួតពិនិត្យ។ សញ្ញា បូក (+) រឺ គុណ (x) គួរជៀសវាង។ ការពន្យល់ពីនិម្មិតសញ្ញាផ្សេងៗគួរតែដាក់នៅក្រោមចំណងជើងនៃក្រាហ្វិក ហើយអក្សរដែលដាក់ក្នុងក្រាហ្វិក គួរមានជាអប្បបរិមា។ អក្សរទាំងពីរនៃក្រាហ្វិក ត្រូវបញ្ជាក់ពីបរិមាណដែលបានវាស់ថ្មីៗ ឬរាប់ហើយត្រូវដាក់ឯកតា SI ក្នុងវង្វង់ក្រចក។

រូបថត : រូបថតត្រូវមានគុណភាពច្បាស់ល្អ។ លក្ខណៈសំខាន់ៗនៃរូបថតដែលត្រូវបានបញ្ជាក់គឺច្បាស់លាស់នៅក្នុងអត្ថបទ ត្រូវតែបង្ហាញឱ្យបានច្បាស់ (ឧ. ដាក់លេខកូដនៅពីលើអក្សរ / ដាក់សញ្ញាព្រួញ)។ រូបថតពណ៌ធម្មជាតិ នឹងត្រូវទទួលយក ប្រសិនបើវាមានសារៈសំខាន់ក្នុងការជួយឱ្យងាយយល់ពីលទ្ធផលផ្សេងៗ។

នាមវត្ថុ : ចំពោះរុក្ខជាតិ, ភ្នាក់ងារចំលងជំងឺ និងកត្តាចង្រៃផ្សេងៗ ត្រូវសរសេរជាអក្សរឡាតាំងក្នុងទំរង់ទ្រេត និងអ្នកដែលបានប្រើប្រាស់/បរិយាយមុនគេ (ឧ. rice, *oryza sativa* L.)។

ខ្នាតរង្វាស់ : ប្រព័ន្ធខ្នាតរង្វាស់អន្តរជាតិ (SI) ត្រូវយកមកប្រើប្រាស់ក្នុងរាល់អត្ថបទដែលត្រូវធ្វើរមកទស្សនាវដ្តីកសិកម្មកម្ពុជា។ ខ្នាតរង្វាស់ផ្សេងទៀតអាចបង្ហាញនៅក្នុងវង្វង់ក្រចកខាងក្រោយខ្នាតរង្វាស់ SI បើសិនជាខ្នាតរង្វាស់ទាំងនេះអាចជួយសម្រួលឱ្យកាន់តែងាយយល់អំពីការងារដែលបានរៀបរាប់ពីខាងដើម។ ខ្នាតរង្វាស់ដែលត្រួតភ្ជាប់គ្នាពីរដង មិនត្រូវប្រើប្រាស់ទាំងនៅក្នុងទំរង់ជាឯកតាស្មុគស្មាញពេកទេ (ឧ.គួរប្រើ mg/sheep. day, មិនគួរប្រើ mg/sheep/day or mg^{-1} $sheep^{-1}$ day^{-1})។ ទស្សនាវដ្តីកសិកម្មកម្ពុជា ត្រូវប្រើអក្សរកាត់ "L" សម្រាប់ឯកតាគិតជា លីត្រ "mL" សម្រាប់ឯកតាគិតជា មីលីលីត្រ។ ខ្នាតរង្វាស់សម្រាប់ប្រើប្រាស់ក្នុងបណ្តុរអ៊ីយ៉ុង (mmol/kg) គួរប្រើចំពោះប្រភេទបណ្តុរ អ៊ីយ៉ុងទោល ឧ. Na^{+}, K^{+}, $CaO.5^{+}$។ ឯកតាដែលណែនាំឱ្យប្រើសម្រាប់បណ្តុរអ៊ីយ៉ុង និងសម្រាប់សមត្ថភាពបណ្តុរអ៊ីយ៉ុង គឺ cmol(+)/kg [ឬ cmol(-)/kg] កន្លែងដែលមានបញ្ហា (+) រឺ (-) គឺសំដៅលើអាយ៉ុង និងការចុង (បន្ទុកអគ្គីសនី)។ ឯកតា ដែលណែនាំឱ្យប្រើសម្រាប់ថាមពលកំដៅអគ្គីសនី គឺ dS/m ប៉ុន្តែខ្នាត mS/cm ត្រូវបានគេទទួលស្គាល់ជាង។

ការវាយតំលៃលើលទ្ធផល

អត្ថបទស្រាវជ្រាវត្រូវមានការពិពណ៌នាដោយសង្ខេប និងច្បាស់លាស់ ស្តីពីវិធីរៀបចំប្លង់ពិសោធន៍ និងលំអិត ក្នុងករណីដែលការវិភាគវ៉ារីយ៉ង់ ឬការវិភាគតាម Regression Models ត្រូវបានប្រើក្នុងការវាយតំលៃដើម្បីឱ្យអ្នកអានអាចយល់ច្បាស់អំពីវិធីគណនារកភាគលំអៀង។ ការវិភាគស្ថិតិ គួរពិពណ៌នា ដោយសង្ខេប ហើយប្រសិនបើចាំបាច់ត្រូវភ្ជាប់ឯកសារយោងជាជំនួយផង។ ចំនួនឯកត្តាតម្លៃមធ្យម និងវង្វាស់អំពីបំរែបំរួលផ្សេងៗគួរត្រូវបានបង្ហាញ។

ឯកសារយោង

ឯកសារយោង : ឯកសារយោង ត្រូវបានលើកយកមកសំអាងដោយឈ្មោះអ្នកនិពន្ធ និងមានដាក់កាលបរិច្ឆេទច្បាស់លាស់ (ប្រព័ន្ធរបស់លោក Harvard) ហើយមិនត្រូវសរសេរជាលេខទេ។ រាល់ឯកសារយោងទាំងអស់នៅក្នុងអត្ថបទ ត្រូវដាក់បញ្ជូលទៅក្នុងបញ្ជីនៅទំព័រចុងក្រោយបំផុតនៃទស្សនាវដ្តី ដោយមានបញ្ជាក់ពីឈ្មោះអ្នកនិពន្ធ ដែលត្រូវរៀបរៀងតាមអក្សរក្រម។ រាល់ឯកសារយោងដែលបានបញ្ជូលទៅក្នុងបញ្ជី ត្រូវតែដូចគ្នាទៅនឹងឯកសារយោងនៅក្នុងអត្ថបទ។ នៅក្នុងអត្ថបទ ឈ្មោះរបស់សហអ្នកនិពន្ធពីរនាក់ត្រូវភ្ជាប់ដោយឈ្នាប់ "និង" ប៉ុន្តែបើចាប់ពីបីនាក់ឡើងទៅ ដាក់ឈ្មោះអ្នកនិពន្ធទី១ រួចបន្តដោយ *·et al.·*។ ចំនួន-ដែលមានឯកសារយោងលើសពីមួយនៅក្នុងអត្ថបទ ឯកសារយោងទាំងនោះត្រូវដាក់តាមកាលប្បវត្តិត្រឹមត្រូវ។ ចំណងជើងឯកសារនិងលេខទំព័រដំបូង និងខាងចុងបំផុតត្រូវបង្ហាញនូវក្នុងរាល់ឯកសារយោងទាំងអស់។ អត្ថបទដែលមិនបានទទួលយកទៅបោះពុម្ពមិនអាចដាក់បញ្ជូលទៅក្នុងបញ្ជីឯកសារ យោងតែអាចបង្ហាញនៅក្នុងអត្ថបទដោយពាក្យថា "ទិន្នន័យមិនបានបោះពុម្ពផ្សាយ" ឬ "ទស្សនៈផ្ទាល់ខ្លួន"។ ប៉ុន្តែការប្រើប្រាស់ឯកសារយោងទាំងនេះគឺមិនត្រូវបានលើកទឹកចិត្តឱ្យប្រើទេ។ អ្នកនិពន្ធទាំងអស់គួរតែយកលំនាំតាមទស្សនាវដ្តី ដែលទើបនឹងចេញផ្សាយថ្មីបំផុតនូវរបៀបបង្ហាញឯកសារយោងផ្សេងៗ ទាំងក្នុងស្បៃវែកៅ និងក្នុងអក្សរសិល្ប៍ផ្សេងៗ។ ចំណងជើងពេញនៃសាមាយិកប័ត្រត្រូវតែដាក់បង្ហាញមកជាមួយដែរ។

ខាងក្រោមនេះនឹងបង្ហាញពីគំរូខ្លះៗ នៃរបៀបដាក់ឯកសារយោងក្នុងអត្ថបទ :

Reference Style (Journal article)

Hubick KT, Farquhar GD, Shorter R (1986) Correlation between water-use efficiency and carbon isotope discrimination in diverse peanut *(Arachis)* germplasm. *Australian Journal of Plant Physiology* **13,** 803-816.

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Blackmore DJ (1996) Are rural land practices a threat to the environment? In 'Soil science _ raising the profile'. (Ed. N Uren) pp. 22-30. (ASSSI and NZSSS: Melbourne)
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Reference style (book)
Lucas GB (1963) 'Diseases of tobacco.'(University of North Carolina: Raleigh, NC)
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Hogan B, Beddington R, Constantine F, Lacy E (1994) (Eds) 'Manipulating the mouse embryo _ a laboratory manual (2nd edn).' (Cold Spring Harbor Laboratory Press: Cold Spring Harbor, NY)

Reference style (thesis)
Silver MW (1970) An experimental approach to the taxonomy of the genus Enteromorpha (L.) Link. PhD Thesis, University of Liverpool, UK.

Reference style (Report or Bulletin)
Lea HW (1957) Report on a visit to the USA and Canada, April 1 to October 2, 1957. Department of Agriculture, Orange, NSW.
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Reference style (Conference Proceedings)
Hayman PT, Collett IJ (1996) Estimating soil water: to kick, to core or computer? In 'Proceedings of the 8th Australian agronomy conference'. Toowoomba. (Dd. M Asghar) p. 664. (The Australian Society of Agronomy: Toowoomba, Qld)
Kawasu T, Koi K, Ohta T, Shinohara Y, Ito K (1990) Transformation of eucalypts (Eucalyptus saligna) using electroporation. In 'Proceedings of the VIIthinternational congress on plant tissue and cell culture'. pp. 64-68. (Amsterdam IAPTC: Amsterdam)

ការអនុញ្ញាសិទ្ធិ

ដើម្បីផ្តល់អត្ថបទឱ្យមកបោះពុម្ពផ្សាយ ត្រូវធានាថាលទ្ធផលដែលបានធ្វើរបាយការណ៍មិនបាន ឬមិនធ្លាប់បោះពុម្ពផ្សាយ ឬកំពុងត្រៀមបោះពុម្ពផ្សាយនៅកន្លែងណាផ្សេង។ សេក្តីសង្ខេបលទ្ធផលនៃការរកឃើញនៃសន្និសីទ ឬនៅក្នុងអត្ថបទបោះពុម្ពផ្សាយណាមួយមិនត្រូវបានចាត់ទុកជាការបោះពុម្ពផ្សាយជាមុននោះទេ។ ទោះបីជាយ៉ាងណាក៏ដោយ ប្រសិនបើមិទ្ធន័យយ៉ាងច្រើនដូចជាតារាង និងក្រាហ្វិក ត្រូវបានបោះពុម្ពផ្សាយមុនហើយនោះ ការបន្ថែមមិទ្ធន័យខ្លះៗទៀតមិនអាចចាត់ទុកថាអត្ថបទនោះជាអត្ថបទថ្មីឡើយ។ ចំពោះអត្ថបទដែលមានអ្នកនិពន្ធច្រើនការផ្តល់នូវលំដាប់បោះពុម្ពដោយទស្សនាវដ្តី ត្រូវបានចាត់ទុកថាមានការឯកភាពគ្នារវាងអ្នកនិពន្ធទាំងនោះ។ ពេលផ្តល់អត្ថបទដល់ទស្សនាវដ្តីអ្នកនិពន្ធទាំងអស់ត្រូវចុះហត្ថលេខាលើបែបបទ "អាជ្ញាប័ណ្ណបោះពុម្ពផ្សាយ"។

អាសយដ្ឋានធំនាក់ធំនងសម្រាប់ការផ្តល់អត្ថបទ

ទស្សនាវដ្តីកសិកម្មកម្ពុជា (Cambodian Journal of Agriculture)

លោកបណ្ឌិត ម៉ែន សារុម នាយកវិទ្យាស្ថានស្រាវជ្រាវ និងអភិវឌ្ឍន៍កសិកម្មកម្ពុជា
ផ្លូវជាតិលេខ ៣ សង្កាត់ប្រទេះឡាង ខណ្ឌដង្កោ រាជធានីភ្នំពេញ ព្រះរាជាណាចក្រកម្ពុជា
ប្រអប់សំបុត្រលេខ: ០១ ភ្នំពេញ ព្រះរាជាណាចក្រកម្ពុជា
ទូរស័ព្ទលេខ: (៨៥៥-២៣) ២១៩ ៦៩២
ទូអក្សរ: msarom@cardi.org.kh / cc: tchanna@cardi.org.kh / cja@cardi.org.kh

រាល់អត្ថបទទាំងអស់ត្រូវត្រួតពិនិត្យដោយអ្នកជំនាញ យ៉ាងតិចណាស់ពី ០២នាក់ ឡើងទៅ។

SUGGESTIONS FOR CONTRIBUTORS TO THE *CAMBODIAN JOURNAL OF AGRICULTURE*

General requirement

Contributions to the *Cambodian Journal of Agriculture* (CJA) may be original reports of research (paper or note), letters to the editor, advertisements, or announcements. Research notes should not be more than two pages in length, while advertisements or announcements should not be more than ½ pages.

Manuscripts (Papers and notes)

Copies

Manuscripts should be submitted electronically, including any tables and figures, the references, table heads and figure captions. Photos must be original or scanned at magazine quality. The manuscript submitted to CJA can be in English (US) or in Khmer. In case the manuscript is in English, the test should be in Times New Roman font with a Khmer translation of the title and abstract in Limon font. For Khmer manuscript, the test should be in Limon font with an English translation of the title and abstract in Times New Roman.

Organization

Title: On the first page of either papers or notes. The title should be short but must accurately identify and describe the manuscript content. The title is, therefore, a highly condensed abstract with a maximum of 12 words.

Author(s): Below the title, list the names of all authors involved in conducting the research works. Separate the names of authors with comma (,) including before 'and' for the last author. Author/paper documentation should be included as a footnote of the first page. This should list the authors name and their complete current address and affiliation in the first paragraph. In the second footnote paragraph, the source of funding could be included if not already noted in the acknowledgements.

Abstract: Each paper must have abstracts: in both Khmer and English. It is limited in a self explanatory paragraph of not more than 250 words for papers and 150 words for notes. State the rationale, objectives, methods, key results and their significance especially for Cambodian agriculture. After the abstract the order of sections is an introduction, which includes a concise review of the relevant literature followed by materials and methods, results, discussion, conclusions (optional), acknowledgement (optional), and references. Results and discussion can be combined, and conclusions can be incorporated in the discussion section.

Style

Tables: Table must be numbered and each must be accompanied by a title. A head note containing material relevant to the whole Table should start on a new line. Table should be arranged with regard to the dimensions of the Journal columns (8 by 21 cm), and the number of column in the Table should be kept to a minimum. Excessive subdivision of column headings is undesirable and long heading should be avoided by the use of explanatory notes that should be incorporated into the head note. The first letter, only, of headings should be capitalized. Use asterisk (*, **, ***) only to indicate statistical significance at 0.05, 0.01, and 0.001 levels of probability, respectively.

The symbol of unit of measurement should be placed in parentheses beneath the column heading. The prefixes for units should be chosen to avoid an excessive number of digits in the body of the Table or scaling factors in the headings. When scaling factors cannot be avoided, the quantity expressed should be preceded by the power of 10 by which the value has been multiplied. Footnotes should be kept to a minimum and be reserved of specific items in the columns.

Horizontal rule should be inserted only above and below column heading and at the foot of the Table. Vertical rules should not be use. Each table must be referred to in the text, and a note in the margin should be indicate the preferred position of the Table in the text. Short table can frequently be incorporated into the text as a sentence or as a brief untitled tabulation. Only in exceptional circumstance will the presentation of essentially the same data in both a Table and a Figure be permitted where adequate, the Figure should be used.

Figures: Unsatisfactory Figures (i.e. in unreadable file formats) will be returned for correction. The symbols + or x should be avoided. Explanation of symbols should be given in the caption to the figure, and lettering of graphs should be kept to a minimum. Grid marks should point inwards; legends to axes should state the quantity being measured and be followed by the appropriate SI units in parentheses.

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Nomenclature: For plants, pathogens, insects and pests, give the Latin binomial in italics and the authority that first mention in the abstract or text (eg. rice (*Oryza sativa* L.).

Units of measurement: The International system of units (SI) must be used in all manuscripts submitted to the *Cambodian Journal of Agriculture*. Other units may be indicated in parentheses after the SI units if this helps in understanding the work reported. The double solidus must not be used in complex groupings of units (i.e. use mg/sheep. day, not mg/sheep/ day or mg^{-1} $sheep^{-1}$ day^{-1}). The CJA uses the abbreviation 'L' for litre 'mL' for millilitre. The units for exchangeable ions (mmol/kg) should be used for single charged ionic species, eg. N^{+},K^{+},$CaO.5^{+}$. The recommended unit for exchangeable ions and ion exchange capacity is cmol(+)/kg [or cmol(-)/kg], where (+)or (-) refers to a unit charge. This recommended unit is numerically equivalent to the non-SI but still widely used mill equivalents per 100g. The recommended unit for electrical conductivity is dS/m, but mS/cm is acceptable.

Evaluation of results

Research paper must contain a clear and concise description of the experimental design used with sufficient detail such that, in the case where analysis of variance or regression models are to be used in the statistical evaluation, the reader is quite clear as to how the error term was estimated. The statistical tests should be briefly described and, if necessary, supported by references. Numbers of individuals, mean values and measures of variability should be stated be made clear whether the standard deviation or the standard error has been given.

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