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Deviation from Optimum Fallow Periods for Dry Rice Fields in Sarawak: The Effects on Rice Production

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Abstract

A predictable decline in rice yields is realized when dry rice fields are farmed after shorter than optimum fallow periods in specified contexts. Where fields are only sporadically and not consistently farmed in fallow periods that are less than optimum, no predictable decline in yields will occur.[1]

Rice farming in the hills and mountains of Southeast Asia tends to be a subsistence effort, although many of these folk may be thought of as marginal peasants.[2] There are even some true peasants among the hill farmers. Swidden, or slash and burn, is the most widely used cultivation method in these upland areas. Despite the importance of swidden, or dry rice farming for the region, there is little concrete information about the relationships among the various components: population density, fallow period, weather, productivity and other factors. Management decisions by farmers and development schemes by governments are equally affected by these components, albeit often in different ways.

This report examines the relationship between the length of fallow and yield in two Lun Bawang villages[3] in north central Borneo (ca. 115° 25′ East and 4° 40′ North). It is based on agricultural data for two consecutive farm years 1975–76 and 1976–77 (yields for the second year were not obtained as it was necessary to conclude the project prior to the harvest). The two villages are located in Lawas District, Sarawak. They are some 37 kilometers apart, their respective valleys separated by a range of low mountains. Nonetheless, there is considerable social exchange between

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1) The research was funded by a Rockefeller Foundation Population Policy Research Grant and sponsored by the Sarawak Museum, Kuching and Universiti Sains Malaysia, Penang.

2) Marginal peasants may produce for a market, but can survive without such earned income. Full-time peasants depend on their market income for survival.

3) The Lun Bawang, who were formerly known as Murut (see J. Degan, SARAWAK MUSEUM JOURNAL 18: 264–280, 1970) number about 20,000 folk. They are found chiefly in the mountainous country of northernmost Sarawak and Kalimantan, with a lesser number in southernmost Sabah. Pa' Lawas is the name given to a composite of three closely related hamlets on the Lawas Damit river. Punang Tengoa is the name given to a composite of four closely related villages on the upper Tengoa river.

the two villages. A good number of folk from the one village are related by descent or marriage to people in the other.

The Lun Bawang use a range of rice farming techniques. Where the land is suitable and their needs sufficiently large, they establish wet rice fields (*lati ba'*). These are similar to wet rice fields found elsewhere in Asia. Such fields can be filled and drained of water at will. They are farmed more or less continuously, but after 5 to 8 years of farming the fields may be left fallow 1 to 3 years "to rest." The only remarkable feature of Lun Bawang wet rice farming is that they accomplish it with human labor. They do own water buffalo (*karibau*) but reserve them for slaughter for their own consumption and for sale.

Dry rice fields are called *tana luun* ("on the land") by the Lun Bawang. Dry rice cultivation involves one, or at most two successive years of crop production. A field is then normally fallowed from 4 to 15 years. When dry rice fields are farmed for two consecutive years, the second crop is most often rice. Alternatively, maize, tapioca and sugar cane are planted as second crops by the Lun Bawang. In the two villages discussed below, second crops are rarely planted.

A sufficient fallow is required so the field may continue to produce adequate yields. Fallowing has two main effects. First, it allows for the suppression of vegetation which would compete with the rice during the growth of the crop. During fallow, the field progresses through a series of vegetative stages. Would-be competitors are gradually reduced by the successive stages of vegetation. At the end of the fallow period, when the field is prepared for the next rice crop, few competitors remain to challenge the rice during the first 4 months. A field is farmed the following year only if the farmer determines that the weed competition, among other things, will not be too bad.[4] A third consecutive year of farming is virtually prohibited by the abundance of weed-competitors and by potentially serious soil degradation.

Protection from soil degradation is the second major effect of the fallow period. In the initial stages of fallow, the vegetation grows up rapidly and shields the field from the effects of rain and sunlight (both its heat and light). In tropical Borneo, the sun and rain act quickly to leach and erode exposed soil.[5]

Recent evidence suggests that the length of fallow has no direct effect on nutrient levels available to growing rice.[6]

4) Social obligations and alternative economic activities are important in these determinations. The two major costs are reduced yields and extra labor input, primarily for weeding. These costs are much less in areas which are less frequently farmed, since weed competition is less to begin with.

5) Hans Ruthenborg, FARMING SYSTEMS IN THE TROPICS, Oxford (1971) pp. 32–34.

6) Personal communication from V. A. Hammons of Universiti Sains Malaysia (1976). In conjunction with this project, 73 soil samples from dry rice fields were analyzed. No significant difference in soil temperatures, moisture or minerals was correlated with length of fallow.

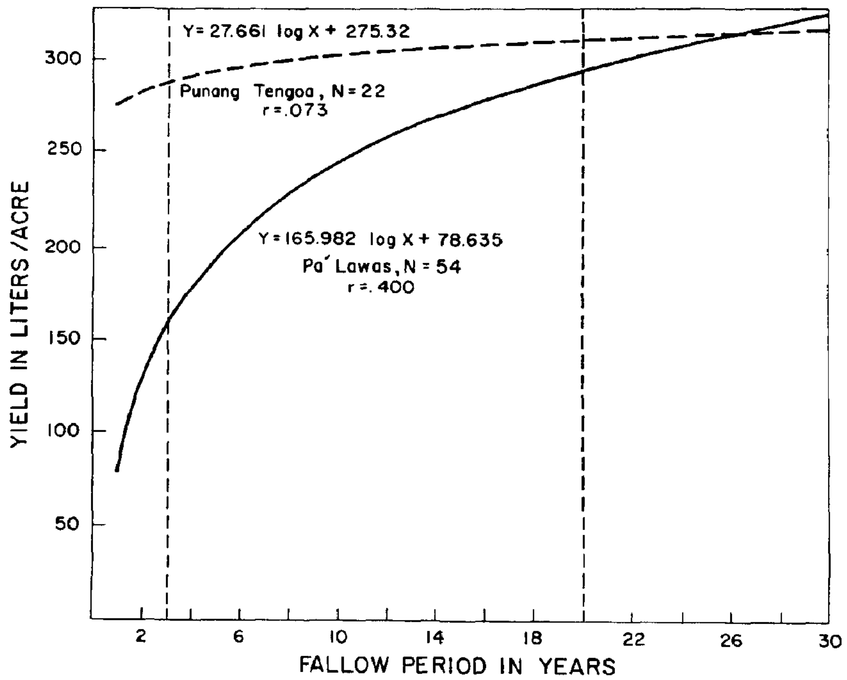

Fig. 1 Log-linear regression of yield on fallow for two Lun Bawang villages. Note that the data for computation is from 3 to 20 years fallow (the area between the dashed horizontal lines).

It is also moot, how much, if any, additional nutrients are made available to growing rice plants from the burning of the field, which occurs just prior to planting.[7] Buring appears to have just two important effects. First, it eliminates the clutter of debris from the clearing and felling operations. Second, it suppresses weeds by scorching seed, spores, shoots and roots that may exist in the field. A well-burned field accomplishes these goals admirably. A poorly burned field is the bane of dry rice farmers.

In some fields the Lun Bawang may use a mix of wet and dry rice techniques. This is so for "swamp rice" fields (*tabur*). These fields may be filled with water but cannot be adequately drained at will. Such fields may be more continuously productive than dry rice fields, but are less productive than true wet rice fields.

The effect of consistently farming dry rice fields prior to their optimum fallow can be seen in Figure 1. This is a graph of the log-linear regression of yield (Y) on actual fallow (X) for Pa' Lawas. The correlation coefficient, $r = .400$, is not large but a test of significance gives $F_{1,52}=9.905$ so that $.01 > P > .001$ (two-tailed). The explanation of the low r (implying that X explains only 16% of the variation of Y) and its high significance is straightforward. In addition to X there are other independent variables affecting Y. Most important of these is local weather during the various stages of cultivation and this data is the

7) Ruthenborg, *op. cit.*, pp. 35–36.

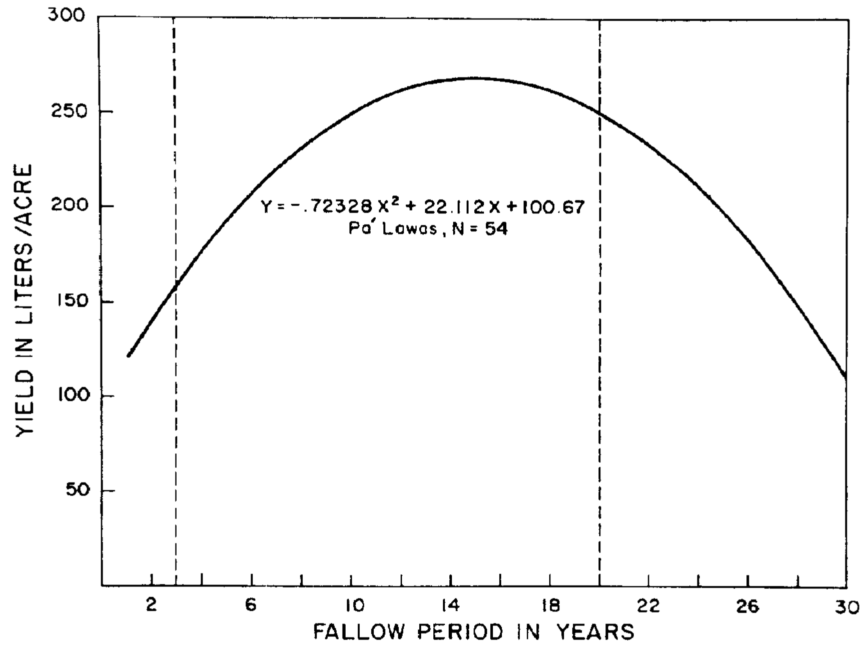

Fig. 2 Quadratic regression of yield on fallow for the Lun Bawang village, Pa' Lawas. Note that the data for computation is from 3 to 20 years fallow (the area between the dashed horizontal lines).

most difficult to gather.[8]

The quadratic regression of yield on actual fallow shown in Figure 2 is likely to be more accurate than the log-linear regression equation, particularly for longer fallow periods. After about 15 years the curve should move slightly downward. There are two reasons for this. First, the maximum benefits of fallowing are obtained within 8 to 15 years for normal fields. Considering what fallowing actually achieves, it is unreasonable to expect any increase in yield once the optimum has been reached. Second, fields which require more than 15 years fallow are usually marginal in soil and topography. Most of these fields are found on the higher slopes of the mountains and are not as productive generally as normal fields.

It should be noted that the limits of the data are 3 to 20 years. Extrapolations beyond these boundaries will likely lead to exaggerated results, especially for longer fallow periods. It seems that a curve of the form aX^3+bX^2+cX+d would give the most reasonable approximation for fallow periods greater than 15 years. This assumes that from the peak yield at about 15 years fallow, the curve will turn down very gently and begin to approach horizontal.

There are two lines of evidence supporting the proposed relationship between sub-optimum fallow farming and

8) Weather particularly affects the success of the burn and the growth and maturation of the rice crop. For example, a field that on the average yields 200 liters per acre may, in adverse weather, yield less than 100 liters per acre. Conversely with optimum weather conditions, that same field may yield 400 liters per acre.

Table 1 Basic statistics for the 1975 sample production and fallow data for the dry rice fields of the two villages, Pa' Lawas and Punang Tengoa. Percent of optimum fallow=actual fallow/optimum fallow.

Village	Statistic	Actual Fallow (in years)	Optimum Fallow (in years)	Percent of Optimum Fallow	1975–76 Yield (liters/acre)
Pa' Lawas (N=54)	High	18	15	150	492
	Low	3	6	33	96
	$\overline{X}$	7.67	10.69	72.7	218
	$\hat{S}$	3.655	2.890	28.90	80.58
	S	3.621	2.866	28.63	79.83
Punang Tengoa (N=22)	High	20	16	188	467
	Low	4	6	33	151
	$\overline{X}$	8.59	8.73	102	284
	$\hat{S}$	4.584	2.414	51.56	85.27
	S	4.478	2.358	50.37	83.32

1) High=the maximum value that a datum took. 2) Low=the minimum value that a datum took. 3) $\hat{S}$=standard deviation of the population. 4) S=standard deviation of the sample.

the correlation between yield and fallow for Pa' Lawas. The first is internal and accomplished by applying a difference of means test to the data for optimum and actual fallow for the sample fields (see Table 1). The result is t=4.824 at 106 df which gives a very low probability, .0005>P (one-tailed, which assumes that actual fallow is predicted to be shorter than optimum fallow). This supports the hypothesis that a substantial number of Pa' Lawas fields are being farmed prior to the completion of their optimum fallow.

The other line of evidence is to compare Pa' Lawas with a sister village. In this case it is Punang Tengoa, a village which is similar to Pa' Lawas in culture, economy and environment. A difference of means test for actual and optimum fallows of Punang Tengoa fields gives t= .1268 at 42 df and P>.40 (one-tailed). This implies that sub-optimum fallow farming occurs much less frequently for Punang Tengoa fields: when it does occur, it may be compensated for by lengthening the fallow period. The result of the log-linear regression of yield on actual fallow for Punang Tengoa compliments these results (see Figure 1). The curve is virtually flat and the correlation coefficient, r= .073. is negligible. This suggests that sub-optimum fallow farming, when it occurs, has little effect on yield.

A difference of means test comparing the two villages for percent of optimum fallow gives a t=4.0391 at 74 df, so .0005>P (one-tailed, assuming Punang Tengoa would have a shorter optimum fallow period). Similarly, a difference of means test comparing yields gives a t= 3.2023 at 74 df, so .005>P> .0005 (one-tailed, assuming Pa' Lawas would

Table 2 Basic statistics for the fallow data from all the dry rice fields of the two villages, Pa' Lawas and Punang Tengoa for the two farming years 1975–76 and 1976–77.

Village	Statistic	Actual Fallow (in years)	Optimum Fallow (in years)	Percent of Optimum Fallow
Pa' Lawas (N=161)	High	21	25	333
	Low	1	5	10
	$\overline{X}$	7.39	10.8	73.3
	$\hat{S}$	4.460	4.342	48.01
	S	4.446	4.329	47.86
Punang Tengoa (N=145)	High	50	20	600
	Low	3	4	50
	$\overline{X}$	13.85	9.15	149
	$\hat{S}$	9.436	3.094	82.68
	S	9.403	3.084	82.40

1) High=the maximum value that a datum took. 2) Low=the minimum value that a datum took. 3) $\hat{S}$=standard deviation of the population. 4) S=standard deviation of the sample.

have the smaller yield).

Briefly then, Pa' Lawas exhibits a modest but significant correlation between yield and actual fallow. It also exhibits a significant difference between its actual and optimum fallow periods. Punang Tengoa, however, shows little difference between its actual and optimum fallow periods and no correlation between yield and actual fallow period. Further, Punang Tengoa has significantly higher yields and percent optimum fallow when compared to Pa' Lawas.

There are two explanations which are most likely for these findings. The first is the hypothesis of this report; that the findings are related to different sub-optimum fallow farming practices and related factors. Alternatively, the findings may be explained by differences in the soil, climate and terrain of the two villages.

The soil of both villages is a loamy sand to clay called red-yellow podzolic which is common to much of Sarawak.[9] Local farmers, who are familiar with both valleys are consistent in their opinions that there is little difference in the soils or the productivity, save that Pa' Lawas soils may be "tiring." Weather patterns and terrain are also sufficiently similar to allow the conclusion that these factors are not important in accounting for the differences in fallow periods and yield. That these differences are the result of differing practices of sub-optimum fallow farming is further supported by a consideration of data for all the dry rice fields of the two villages for the two years under study (see Table 2).

Data on the actual fallow period for

9) J. Wall, SOIL SURVEY REPORT OF THE SABANGANG AREA, Sarawak Department of Agriculture (1964). Also SOIL MAP OF SARAWAK, Sarawak Department of Agriculture (1968).

all (N=145) Punang Tengoa dry rice fields show only 12% were fallow for 5 or less years. 43% of the fields were fallow for 6 to 11 years and 44% were fallow for 12 or more years. Data on the actual fallow period for all (N=161) Pa' Lawas dry rice fields show a reverse distribution. 48% of the fields were fallow for 5 or less years, 34% were fallow for 6 to 11 years and 17% were fallow for 12 or more years. The difference in the distribution of fallow periods for the two villages is significant at .001 >P (X^2=51.45 at 2 df).[10]

The difference in actual fallow periods is also seen in the respective means, for Pa' Lawas, $\overline{X}$=7.39 and Punang Tengoa, $\overline{X}$=13.9.[11] At the same time, the average actual fallow period for Pa' Lawas fields is much below the average optimum fallow. A difference of means test comparing actual and optimum fallow gives t=6.951 at 320 df so that .0005>P (one-tailed).[12] By contrast, the average actual fallow for Punang Tengoa fields is much above the average optimum fallow. A difference of means test comparing these for Punang Tengoa gives t=5.699 at 288 df, so that .0005>P (one-tailed).

While there seems to be little difference between the mean optimum fallow periods for the two villages, that difference too, is significant. A difference of means test comparing for optimum fallow (N=306) gives t=3.790 at 304 df and .0005>P (one-tailed, assuming Pa' Lawas would require a longer period). The increase in optimum fallow probably reflects the need to allow sub-optimally fallowed fields a longer than usual period of regeneration. The dynamics of fallow growth in this situation are, unfortunately, not yet well understood.

Pa' Lawas, then, has a significantly higher optimum fallow period and much lower mean actual fallow period than does Punang Tengoa. Further, actual fallow for Pa' Lawas is significantly lower than its optimum fallow, with the situation being reversed for Punang Tengoa. This is consistent with the hypothesis that Pa' Lawas farmers are regularly farming fields at sub-optimum fallow, a situation that does not pertain to Punang Tengoa.

Demographic data suggest why Pa' Lawas farmers practice sub-optimum fallow farming more intensively. Pa' Lawas has a population of 494 persons and 24 square kilometers of arable land. Its population density is about 21 persons per square kilometer of arable land. Punang Tengoa has 337 persons and 37 square kilometers of arable land for a comparable population density of about 9 persons per square kilometer. This

10) Given the following order of fallow, 5 or fewer years, 5 to 11 years, 12 or more years, the number of fields for Punang Tengoa are 18, 63 and 64 and for Pa' Lawas 78, 55 and 28.

11) Because the actual fallow data is not normally distributed for either village, a difference of means test to compare the two villages is not warranted here.

12) Despite the maldistribution of actual fallow data, an internal comparison with optimum fallow is justified on the grounds that these figures ostensibly represent different facets of the same basic population.

difference is primarily a result of their respective locales.

Pa' Lawas is only 7 kilometers via an all weather cobble road from Lawas town, the local trade and government center. Lawas has a well-supplied commercial area, good medical facilities and secondary education through the tenth grade. It is the local focus for politics, administration, and sea and air transport. For the Lun Bawang, Lawas town is also the primary center for obtaining wage labor. Since the early part of the century, these features have attracted a a slow but steady flow of immigrants to Lawas from surrounding rural areas.

Pa' Lawas, because of its proximity to Lawas town and ethnic composition, has attracted numbers of Lun Bawang settlers from the interior.[13] This added increment to the population has further increased pressure on Pa' Lawas farmland.[14] Specifically, there is insufficient farmland available around Pa' Lawas to permit all fields to lie fallow for their optimum periods. Of necessity, some fields must be farmed at a sub-optimum fallow. This practice will expand if yields decline, even though the population may stabilize. By contrast, Punang Tengoa is more remote and does not suffer from immigration. There, sub-optimum fallow farming, when it occurs is done for convenience, not of necessity.[15]

Punang Tengoa is 35 kilometers by air from Lawas town. A periodically impassable logging road winds up and out of the Lawas valley and accross the low mountain ridge separating the two valleys. It ends about two kilometers downstream from Punang Tengoa's central hamlet. Withal, Punang Tengoa is not truly isolated. It has an airfield and there are twice-daily flights two times a week provided by MAS, the government air service. Also, there are numerous unscheduled flights by other aircraft as well. Punang Tengoa has a primary school, field dispensary, and agricultural station, all manned by government personnel, many of them Lun Bawang.[16]

There is, then, considerable pressure on Pa' Lawas farm lands. Even if the population stabilizes at its current level, pressure will continue for sub-optimum fallow farming. This is because the population is at, or has already exceeded, the optimum long-term fallow carrying capacity for dry rice farming. If the

13) Lawas town is predominately Chinese and felt by the Lun Bawang to be a not entirely suitable place to settle. There are also a few Indian families resident in town and some larger Malay settlements in the vicinity.

14) A considerable amount of Lun Bawang farmland in the immediate vicinity and to the west of Lawas town went over to the Chinese in the first quarter of this century.

15) It requires considerably less labor input to prepare a field that has only fallowed for half its optimum time: the smaller tree size makes felling much easier. Ideally the field should then be allowed to fallow for a longer than normal period (from its optimum fallow of say 8 to 10 years, the field might be allowed to fallow 12 to 15 years). The additional time does not greatly increase the labor requirements at felling, since the growth of the larger trees slows in girth.

16) It could be argued that the extension of these services into rural areas by the Malaysian government has been of major importance in inhibiting a larger rural to urban migration.

optimum has been exceeded, then there will be a gradual decline in dry rice yields. Demand, however, will remain at least constant. This will put additional pressure on farmers to bring more land into cultivation per year to satisfy the demand. Thus, sub-optimum fallow farming would become even more pervasive.

With an average fallow of 7.4 years, the situation of Pa' Lawas is not yet serious. It can be seen from the regressions in Figures 1 and 2, however, that as the actual fallow declines below five years, yields begin to decline radically. At this point there are 3 responses that can occur: 1) emigration, 2) acceptance of a decline in standard of living, 3) a change or changes in economic technology.[17] For the situation above it could well be a widespread shift to wet rice-farming. Any one, or some combination of these responses may obtain, depending on local circumstances.

All dry rice farms and the associated communities can face a similar situation as their populations approach and exceed local carrying capacity. This will be signaled by regression curves similar to the one for Pa' Lawas. Once such a situation has been established and the position of the village on the curve determined, a reasonably accurate estimation of the seriousness of the situation can be made. Amendment of the situation may then be possible without severe hardship or dislocation.

17) E. Boserup (CONDITIONS OF AGRICULTURAL GROWTH, Aldine, 1965) has perhaps expanded on this position most completely.